Isdological Book

DEVELOPMENT OF GEOGRAPHIC KNOWLEDGE IN ANCIENT INDIA (HINDUISM & ITS OFFSHOOT ĀRMS eg- JAIN, BUDDHISM)

Vishnu Chandra Arya

33

BY
PROF. MAYA PRASAD TRIPATHI

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Par

Prof. MAYA PRASAD TRIPATHI

"Une étude scientifique et critique de l' epistomologie et des idées de la science de géographie en Inde antique."

Die Entwicklung des geographischen Wissens im
alten Indien. (German)

von Prof. MAYA PRASAD TRIPATHI

"Ein wissenschaftlicher Über blick über die Epistemologie, und auch über den Begriff der geographschichen Wissenschaft im alten Indien".

Развитие географических познаний в древней Индии

проф. МАЯ ПРАСАД ТРИПАТХИ (Russian)

,, Научный и критический обзор взглядов и описаний в географической науке древней Индии''.

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TRANSLATIONS FROM ENGLISH

१. दृष्टिदात्री (U. S. I. S.).
२. भूगोल—आर्थिक, व्यापारिक, संसार.
३. भूगोल—भारत, पाकिस्तान.
४. जहाँगीर (डा० बेनीप्रसाद प्रणीत).
५. मीर कासिम.
६. लार्ड क्लाइव.
७. भारतीय संविधान.

PREFACE

This field of geographic-cum-Indological investigation remained totally unearthed and unexplored. Its veiled mystery and novelty scintillated with great fascination for me ; besides, its unravelling was long-awaited and had become a crying need of the day, specially when geography came to occupy its rightful place in India in the modern era. This incentive and inspiration propelled me to undertake this work. It covers the period from the Vedic times to 1200 A.D.

In the investigation all the material which could be available has been fully utilised and profoundly chaffed. It is just possible that new discoveries of archæology, other sources of Indology and manuscripts may throw further light on the subject, still in the present dissertation attempt has been made to be as much complete, as much uptodate and authentic as is possible. (The manuscript was finished by March, 1960 and was published in toto immediately after that in various reputed research journals. However, by the time of its going to press in 1969 in the persent form, a few additions and alterations have also been made).

A word about the structure of the work. Incorrect and legendary imformation is frequently omitted, unless its discussion and analysis have become inevitably expedient for marshalling and tracing the link. If a fact is simply repeated at different places, only one or two references to it have been cited and deemed adequate. Identification of names and places has been merely touched upon under inevitable circumstances or omitted, for too much literature has already accumulated on it. As a necessity, the approximate dates of all the works referred to in the thesis are given in the bibliography.

An appendix containing a list of selected technical terms is provided at the end to enhance the utility of the research product.

The ultramodern scientific dialectics of the orientation and presentation of the monograph and its absolutely original and fascinating discoveries along with the novel factualities easily characterise it to serve as a text book for the Acharya Classes of the Sanskrit Universities and M. A. students of geography and Indology and Ancient History and Culture of India in all Indian and foreign Universities. Research scholars would specially find it a fountain source of ample inspiration and guidance, opening up further vistas for the devolutionary spade work and spectroscopic historiography. It would prove of much attraction and utility also to other classes of lovers and readers of the saga of civilization.

Maya Prasad Tripathi

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Development of Geographic Knowledge In Ancient India

CHAPTER I

Cosmogony and Cosmology

The nucleus.

Eternal and universal inquisitiveness about the Cosmos.

Space, Time, Ether, continuum and the heavenly bodies.

Comparative vista of the Ancient and Modern cosmogony and cosmology.

Specific size and shape of the universe—old and new concepts compared.

Indian tradition of dissertation-writing on cosmogony and cosmology.

CHAPTER I

COSMOGONY AND COSMOLOGY

Cosmogony and cosmology are now generally conceived or form a part of geography in-as-much-as dwelling at length on this latter particular branch of knowledge, it becomes naturally essential to investigate into the origin of our planet in the cosmos; and in the same fervour of genuine and perfectly relevant quest of the unknown, it inevitably induces another concomitance to thrash out peremptorily the conundrum of creation of the universe in general as a generic question, starting point or initial problem; and the very context and sequence of delving into those mysteries devolve to furnish as much accurate an account of the macrocosm as possible.

The natural inquisitiveness in man has been goading and piloting the cosmogonic and cosmological enquiry from the days immemorial—from the first dawn of civilization and speculation. In different times and climes the speculators at different levels of civilization and culture envisaged and fostered diverse ideas, fancies, imaginary beliefs or scientific conceptions regarding that enquiry. It was due to the fact that before the birth of natural sciences in its real sense, philosophy, religion, ritualism, orthodox dogmatism, superstitions and a priori scientific theorisation or truths were all jumbled together or the last was even ousted or sacrificed for the former ones.

Whatever might have been the state of affairs in this realm, it is a fact that all great ancient civilizations and religions, for example, the Greek, Babylonian, Egyptian and Christianity, Judaism and the like had quite rich speculation on cosmogony and cosmology. So was the case with the great Indian civilization and Brahmanism or Hinduism and its various offshoots which include Buddhism, and Jainism.

Rather as will be seen in the sequel, Indians took those two branches of enquiry to such an appealing consummation that they not only remained unexcelled in the field, but also were copied by the peoples of other lands or influenced them very considerably.

The Vedas being the earliest Indian literature discovered and known so far, contain the most ancient or the first Indian speculation on the subject of cosmogony and cosmology.

The mystery of the origin of the universe has ever been a riddle to human mind and it still continues to be so. To the Ṛgvedic Āryans also it was a great enigma. Towards this the Ṛgveda (C. 3000 B. C.) made beautiful poetic approaches of interrogation and paradoxes[1] and at several places has attempted to provide descriptive guesses on scientific basis.

The first explanation of the formation of the universe is given to be that it was created like a building—a miraculous feat of engineering[2] or, in other words, it is "the result of the mechanical production, the work of carpenter and joiners' skill." This concept very favourably compares with the nineteenth century speculation of science (led by Helmholtz, Lord Kelvin, Maxwell and others).[3]

The other Ṛgvedic theory represents it to be the result of the natural generation.

In connection with the Ṛgvedic cosmogony the hymns 72, 82, 121, 129 and 190 of the tenth Maṇḍala are most important. In two hymns the origin of the universe is postulated to be a kind of evolution of the existent (सत्) from the non-existent (असत्).[4] The hymn 190 states that from heat was produced order (ऋत): then night, the ocean, the

1. X. 129. 6-7; X. 72. 3-4; X. 81. 24.
2. II. 15.3 and others-vide Wallis "The Cosmology of the Ṛgveda".
3. J. Jeans-The mysterious Universe. p. 28.
4. X. 72. 2-3. X. 129. 4.

year; the creator (धाता) produced in succession the sun and the moon, heaven and earth, air and ether. In the former evolutionary speculation, the anticipation of Darwin's Theory of Evolution can very legitimately be sought and recognised. As regards the latter statement of heat and the like, it can be observed that modern physics also attempts to reduce the entire universal phenomena to electricity—a form of heat.[5]

The two mantras X. 82.1 and X. 121.1 represent the creation to have started with the origin of water and the cosmic golden egg (embryo) (हिरण्यगर्भ) which very well fits in the geological and biological evolution of the earth with the water age, origin of Zoophytes, primeval fishes, reptiles, invertebrates, vertebrates and mammals.

H. W. Wallis[6] says—"The origin of the world was, therefore, held to have been due to a primeval sunrise or primeval thunderstorm." It very discernably smacks of the modern theories of cosmogony.[7]

The same author further observes "We find mention in one hymn of a primordial substance or unit of which the universe was developed."[8]

The modern ideas of primordial gaseous, nebular storm and attraction and collision of immense stars and genesis of bodies in the universe can further be read in the following lines :—

"When ye, O Gods, stood firmly embracing one another in the formless depth, thence there arose from your feet a thickening volume of dust as from dancers".[9]

---

5. J. Jeans, p. 69.
6. p. 56.
7. The Physical Basis of Geography, Chap. I by Wooldridge and Morgan.
8. I. 164. 6, 46; X. 82. 6.
9. X. 72. 6.

"Apparently, the Āśvins stirred up the dust, which formed heaven and earth, and gods were so pleased with the production that they wished to have them in solid masses".[10]

Extolling the cosmogonic and cosmological ideas of the Ṛgveda, Wallis says—

"It is a not infrequent occurrence that a whole complex of the modern ideas finds its most happy and appropriate expression in an old term, or a proper name or attribute or in the words of an ancient saying.[11]

Like the Ṛgveda the Tattirīya Sanhitā[12] (C. 3000 B. C.) and Yajuh-Vājasaneyī Sanhitā[13] also propound that the universe originated from the (हिरण्यगर्भ) (golden embryo). The Vājasaneyī-Sanhitā says in a sacerdotal and mythological fashion that the four castes (चतुर्वर्ण) and the moon, the sun, the air, the sky and the earth were born from the various limbs of Brahmā.[14] But later on in the seventeenth chapter of this Sanhitā are embodied such cosmological speculations as can be said to be scientific to a considerable extent or at least their line of thinking is based on a scientific ground. Here also the modern nebular hypothesis of cosmogony is thus referre to—नीहारेण प्रावृता जल्प्या.[15]

According to Vedic conception the heaven and earth were the same in days of yore and were later separated.[16] Further the Vedas purport to promulgate that the heaven, earth and time—all the three are born from the golden embryo, or in other words all space and time form the parts

10. Vide sense of X. 24. 4-5 Wallis p. 43.
11. p. 90.
12. TS. IV. 2. 8. 2. (Eng. Trans. Keith)
13. VS. XXIII. 1 (Eng. Trans. Griffith)
14. XXXI. 11-12-13.
15. 17. 31 (Edited by Rama Sakala Mishra with उवट and महीधर भाष्य.
16. Ibid. 34. 45 and others.

of a single entity. This very favourably compares with the ideas of Space-Time continuum[17] of the theory of Relativity of Prof. A. Einstein.

The Aitareya Brāhmaṇa[17a] in its metaphysical and religious strain speaks thus of the origin of creation—

"Prajāpati desired 'May I be propagated; may I be multiplied'. He practised fervour (penance); having practised fervour he created these worlds; the earth, the atmosphere, the sky. He brooded over these worlds; from these worlds when brooded over these luminaries were born; Agni was born from the earth, Vāyu from the atmosphere (अन्तरिक्ष); Ādityas from the sky (दिव:). He brooded over these luminaries." The Taittirīya Brāhmaṇa also accepts that first of all water was created, and afterward the earth.[18] Speculating further on cosmogony it observes in beautiful poetic language in the form of a series of questions that it appears impossible to unravel the mystery of creation, its order and creator.

---

17. Ancient Indians knew that Space and Time both are relative. They had a very clear-cut conception of the fact that under certain circumstances (e. g. for photons or photon rockets of modern science) the progress of time is slowed down and ultimately it may stand still. The story of King Raivata (Viṣṇu Purāṇa IV 1. 67-77) informs us that when he had gone to the abode of Brahmā and was listening there to a musical performance, the ages that passed away during it seemed to him a moment. Concept of Brāhma day and night in the Indian measure of time also corroborates this. For the scientific interpretation of the Raivata story I am indebted to my younger brother Sri Satya Prakash Tripathi, M. Sc. P. E. S. Head, Maths Deptt, Govt Degree College, Raigarh (M. P.).

17(a) Keith--Eng. Trans.--V. 32. p. 256.

18. Aṣṭaka 1. Chapter 1. Anuvāk 3.

From the sixth Kaṇḍikā of the Śatapatha-Brāhmaṇa (not later than 1000 B. C.) also we gather good information on the subject of "creation of universe." It has to say that first of all water was created[19], then egg, then foam[20] then clay, mud, saline soil and sand, gravel, rock, ore, gold, plants, trees.....[21]. Later on is described the origin of the wind, sunmotes and the air[22]. VI. 1. 2. 3 says. "And that which was shell became the sky." Then is given the origin of the sun, the moon, stars and various quarters[23]. But there is little scientific in it.

It has already been said in the preceding paragraph that the shell became the sky. At another place the Śatapatha Brāhmaṇa imagines the universe to be of the form of a tortoise. "That lower Kapāla of it (tortoise) is this world, for that Kapāla is firmly established, and firmly established is this world; and that upper Kapāla is yonder sky, for it has its ends turned down, and so has that sky its ends turned down, and that which is between is that atmosphere : verily that (tortoise) represents this world."[24]

It is strange that this spheroidal or hemispherical concept of the universe and sky very well tallies with the description of universe given or postulated by J. Jeans. He says, "To sum up, a soap-bubble with irregularities and corrugations on its surface is perhaps the best representation, in terms of simple and familiar materials, of the new universe revealed to us by the theory of relativity. The universe is not the interior of soap-bubble but its surface....."[25]

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19. SB. VI. 1. 1. 9.
20. VI. 1. 1. 13.
21. VI. 1. 1. 13.
22. VI. 1. 2. 2, Compare J. Jeans "The Mystrious Universe" Chap. 9.
23. VI. 1. 2. 2-4.
24. VII. 5. 1. 2.
25. The Mysterious Universe, p. 139.

In this connection, another picture of universe can be read in the Chāndogyopaniṣad, though it is mostly absurd. It visualises the universe to be like a treasure chest. "The chest, having the atmosphere for its inside, and the earth for its bottom, does not decay. The quarter of space are its corners and its upper lid is the sky. This chest is one containing wealth and within it rests everything here."[26]

Earth was in the beginning a part of some other entity or body is again indicated by these lines—

".....at first these two worlds (heaven and earth) were together; and when they parted asunder, the space which was between (Antarā) them became that air (Antarikṣa); for Ikṣa (visible thing) has come between (Antarā), they said, whence Antarikṣa (air)."[27]

The Vedic concept of golden egg springing from all waters is repeated here also.[28] The Gopathabrāhmaṇa (almost the latest of the Brāhmaṇas) speaks that the ocean originated from Brahma (ब्रह्म).[29] It further informs that Brahmā created all lokas (worlds), all inhabitants, all types of life and heavenly bodies.[30] The same statement is extended to say that almighty created the earth, fire, vegetation, east and spring season.[31] Some mystic ideas regarding other aspects of creation are expressed in 1. 18-19-20 (Gopatha Brāhmaṇa)

A more orderly form of cosmogony is narrated in the following lines of the Taittirīyopaniṣad[32]—

"तस्माद्वा एतस्मादात्मन आकाशः संभूतः। आकाशाद्वायुः। वायोरग्निः। अग्नेरापः। अद्भ्यः पृथिवी। पृथिव्या ओषधयः। ओषधीभ्योऽन्नम्। अन्नात् पुरुषः।"

---

26. III. 15. 1.
27. VII. 1. 2. 23.
28. SB. XI. 1. 6. 1-2-3.
29. I. 3.
30. I. 16.
31. I. 17.
32. (Brahmavalli Part I) II. 1.

"From that or that yonder self sprang the sky. From the sky the atmosphere. From the atmosphere, the fire. From the waters, the earth. From the earth, the vegetation. From the vegetation, the cereals. From the cereals, man (पुरुष)."

The Praśna Upaniṣad has the following :—

"This embodied (incarnate) time is the great ocean of creatures. In it abides he who is called (सवितृ) (the sun as the begetter) from whom, indeed are begotten the moon, stars, planets, the year and the rest".[33]

The Paiṅgī Upaniṣad (prior to the Buddhist literature) belonging to Śukla Yajurveda advances a concept of elemental creation; which is quite unique and divergent in such type of literature, "He (the creator of the world) desirous of creating, embracing the quality of inertia (तमस्) desired to change the subtle elements into gross ones. Dividing each of the elements measured at the time of creation into two and again sub-dividing each (first equal part) into four equal parts each and mixing each of the four sub-divided equal parts with each of the four (second) equal parts of the other four elements and thus forming five heaps (of five sorts of each); out of the elements thus quintuplicated he created many crores of Brahmāṇḍas (macrocosms), fourteen worlds appropriate to each (of these macrocosms) and globular gross bodies (.....तत्तद्भुवनोचित-गोलक स्थूलशरीणाणि-असृजन्) appropriate to each of (these worlds)."[34]

Discussing the cosmogony dilated in the Vedas and Brāhmaṇas, Prof. M. Winternitz remarks, "Very noteworthy, too, is the fact that in the Brāhmaṇas (and in the Vedas generally) there is no one creation legend, which, as for instance the Biblical legend in Europe, has found more or less general recognition in India, but that we find a great number of creation legends, containing the most diversified ideas and

33. VI. 17.
34. I. 7

speculations, which cannot be made to harmonise with one other at all."[35]

But this statement is merely partially true. In the light of what has been said and cited in the preceding paragraphs and further detailed studies of such hymns and verses of Vedic literature, it can be easily seen that amidst this diversity, there is a peculiar unity. To put in other words, inspite of the variance in details, the quintessence is the same throughout. Almost everywhere except at a very few places, is met the same idea of waters springing first, and in it the golden embryo or universal egg (हिरण्यगर्भ).

Of course, it is true that in the vast Vedic literature, chronological improvement in the cosmogonic and cosmological ideas can seldom be traced, rather at places deterioration can easily be perceived. In this connection, Wallis observes, "The cosmological guesses string together in the other Vedic collections, and even in the Brāhmaṇas, occasionally bear a more primitive character than those in the Ṛgveda."[36]

The Vālmīki Rāmāyaṇa

The theme of cosmogony is touched upon in Book II and Book VII (Book implies Kāṇḍa). Verses II.11.3-4-5 say "water was everywhere. The earth was constructed therein. Then sprang the self-created Brahmā along with all the celestials. Having become a boar, he raised up the earth and along with his sons subdued souls created everything. Brahmā eternally existing through all time and incapable of decay, sprang from the sky (आकाश)"[37]. Here we find the general belief of Indians that the creation started initially with water. This has already been seen in the Ṛgveda also (10.82.1 and X.121.1). Mention of boar in its legendary implication can be interpreted, if we like, to give a very distant and faint semblance of the evolution

35. A History of Indian Literature, Vol. I. p. 222.
36. The Cosmology of the Ṛgveda.
37. Eng. Trans. MND. q. 481.

of animal life on the earth or in general terms the "Theory of Evolution." The last sentence points to the creation having been originated from the existent (सत्) and (non-existent) (असत्) शून्य or sky at the same time. It gives a glimpse of the Ṛgvedic hymns 72, 129 and others of the Maṇḍala X.

VII. 104. 2-3-4 gives further enunciation about the cosmogony. Time, the great destroyer of all, speaks to Rāma, "Thou didst, in thy pristine birth, beget me on Māyā—I am Kāla, the destroyer of all. Lord Brahmā, the father of all creatures, has said thou didst promise to preserve the three worlds. Formerly when having slain all animals by the Māyā thou went asleep in the waters of the mighty deep, I was born. Thereafter thou didst create the huge-bodied Ananta, living in the waters as the king of serpents."[38] These lines point to four facts (i) creation originates and exists in a cycle, (ii) water in the primary stage (alluding implicity to some extent to the Vedic and later Hiraṇya-garbha—golden embryo conception), (iii) creation of infinity (it is expressed in the legend style, a very well-known characteristic of ancient Indian literature); and (iv) the genesis of time as a dimension of a concrete reality (compare the concept of continuum in the Theory of Relativity[39] and the Vedic ideas discussed on page 4, para 5). These above verses of the Rāmāyaṇa (2, 3, 4) appear to be a little superior to those of Book II mentioned prior to the former ones. Book VII. 72 (MND. p. 1757) also refers to the background of cosmogony. But on the whole the cosmogony of the Rāmāyaṇa is extremely sketchy and much inferior when looked at through the chronological evolution of ideas beginning from the Ṛgveda where cosmogony is decidedly of superior order.

The Mahābhārata

In the domain of cosmogony the Mahābhārata follows the old traditional myth and concept of the Ṛgveda, but in a

38. M. N. D. p. 1921.
39. The Mysterious Universe, p. 125, 134, 137.

haphazard and very clumsily compressed way. The details given are not only too brief but their dilation is also merely cursory and casual. In the Ādi-Parva it is said that first of all was created an extremely supernatural (महादिव्य) mighty egg, from which was produced every other thing, several living beings, water, earth, all space and time.[40] The Harivanśa, suppliment of the Mahābhārata, also informs that the sky, earth, quarters, time, lightning, cloud, rainbow and birds, gods, demons, human beings—all originated from the Hiraṇyagarbha (golden embryo).[41]

The Manusmṛti

In the Manusmṛti[42] we come across considerable details of cosmogony, which here and there embody some scientific truths also. The description, however, opens with the mention of the creation of the golden egg, which is said to be "in brilliancy equal to the sun", perhaps pointing to the fact that the universe or creation originated with or from some highly effulgent mass or star. Then the golden egg was divided into two halves forming heaven and earth, and between them the middle sphere, the eight points of horizon, and the eternal abode of waters. The concept of joining of particles described in verses 16 to 20 and 27 of the chapter one compares very well with that given in the Paiṅgī Upaniṣad, already referred to.

Then from fire, wind and the sun were drawn-forth time and division of time, the lunar mansions and the planets, the rivers, the oceans, the mountains, plains and un-even ground, which were followed by the creation of Yakṣa, Rākṣasa, Piśāca, Gandharva, serpent, deities, bird-deities, lightning, clouds, falling meteors, comets, heavenly lights of many kinds, monkeys, fish, birds, cattle, men, carnivorous beasts, worms and beetles—this was the whole creation of inanimate (स्थावर) and animate (जंगम) objects.

40. I. 1. 29-37. (MND. p. 2).
41. I. 1. 29-32, 39-40.
42. I. 8-25, 27, 34 to 41.

In the verse 19 of the said chapter is stated that this world originated—the perishable from the imperishable, which purport to promulgate that Matter is indestructible.

Thus it can be evidently seen that in the contemporary ancient Indian literature, the cosmogonic speculations of the Manusmṛti are of the best order and most satisfactory inspite of their containing the Vedic traditionalism.

Philosophic systems

In the Vaiśeṣika and Sāṅkhya systems of Indian philosophy occur some casual but important references to the cosmogony which deserve some notice.

The Vaiśeṣika system (pre-Buddhistic) of Kaṇāda propounds that the world comes into being through the conglomeration of atoms. These are combined into dvyaṇukas (द्वयणुक) and the dvyaṇukas combine to form trasareṇu (त्रसरेणु). And "The world spreads out in space in series of event which occupy time. Space and time are divisible in thought but not into atoms."[43]

Kaṇāda has not given any complete account of creation. Only references are found in his aphorisms in books two, four, five, seven and ten. Further, these sufficiently prove that he accepted the general traditional view of cosmogony.

In the cosmogonic references of Sāṅkhyasūtra (of Kapila before 400 A.D. ?) We come across the theory of evolution,[44] indestructibility of matter[45] and concept of successive[46] and continuous creation.[47] Book two of the Sāṅkhyasūtra tells us how the creation is formed out of the primal principle. In Book third occur references to creation of celestial world, infernal world and the worlds of mortals.[48] Sutra 15 of Book five says that world has a beginning.

43. The Classical Age--p. 460.
44. I. 96.
45. I. 121
46. II. 2.
47. II. 4.
48. III. 48-49-50.

The Purāṇas

Cosmogony forms one of the five avowed characteristics of the Purāṇas, and as such is included in all of them, except the two, namely, the Bṛhannāradīya and Vāmana.

In almost all the Purāṇas, the origin of creation is said to be from waters, a golden embryo and all its well known paraphernalia. Generally in details also they agree with each other, with the exceptions of a few points here and there.

It is queer to notice that the Liṅga Purāṇa makes a very significant departure on the very old and established tradition of acknowledging only one golden embryo to be the source of all creation. It asserts that creation started not from one golden egg, but from several such eggs which each gave birth to fourteen Bhuvanas—"अण्डेऽवेतेषु सर्वेषु भुवनानि चतुर्दश".[49]

The cosmogony dilated in the Maheśvarakhaṇḍa of the Skanda Purāṇa has got some further special features.[50]

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49. 53. 48. The Viṣṇu Purāṇa also speaks of the existence of infinite number of universe and crores and crores of such type of eggs (ब्रह्माण्ड) in the nature (अंश २, अ० ७, श्लोक २६, २७). But in the description of the initial creation, it has referred to one and only one egg (अंश १, अध्याय २, श्लोक ५४) or (हिरण्यगर्भ) according to commentator Viṣṇucitta in the commentary of श्लोक 57 of chapter 2, Anśa 1). Also Cf. (हिरण्यगर्भो ब्रह्माण्ड भूतो ब्रह्मा"—अंश ४, अध्याय. १, पद ५)

M. N. Dutta, drawing upon Prof. Wilson's rendering of the Viṣṇu Purāṇa, translated the above mentioned śloka 26 and 27 thus: "This Prakṛti, 0 Muni, is the source of the endless universe and of thousand, ten thousands and millions and thousands of millions of mundane eggs".

50. 37. 6 to 15.

According to it, creation primordially begins with twenty four elements (three guṇas+five gross elements) (भूत) +five objectivities (विषय)+ten sense organs+asat (मनस्) These were first transformed into bubbles and from them sprang up the beautiful egg—the world egg—(ब्रह्माण्ड) which gave birth to trailokya (Heavens, earth and the nether world).

From the study point of view cosmogonic speculations of the Viṣṇu (3rd. Century to 4th Century A. D.), Bhāgavata (C. 6 Century A. D.), Markaṇḍeya (3rd. Century to 4th. Century B. C.), Bhaviṣya (c. 400 B. C. to 300 A. D.), Skanda (prior to 7th Century A. D.), Matsya (6th Century B. C. to 400 A. D.) and Brahmāṇda (c. 3rd. Century to 5th. Century A. D.) Purāṇas are more important. They represent the more common and general trend of thoughts.

The Viṣṇu Purāṇa contains the following description of creation :

"Those commencing from Mahat (intellect) and ending in Viśeṣa (nine totally different eternal substances—soul, time, place, ether and the five atoms of earth, water, light, air and mind) brought forth an egg. And that egg resembling a watery bubble, fostered by the elements, attained dimensions.....And.....in that egg sprang mountains and islands, and seas, light, and numbers of worlds and deities, Asuras and human beings. And that egg was environed ten times successively with water, fire, air, ether and Bhūtādi (the originator of elements), and the Bhūtādi was surrounded in the same way by mahat (intellect), and mahat along with all those was also covered by Avyakta (unformed matter). As the internal coconut fruit is covered by the external rind, etc., even so was the egg surrounded by the natural coverings."[51]

According to this Purāṇa, primevally the whole universe formed a single ocean.[51a] Then the supreme deity assuming

51. Viṣṇu Purāṇa 1. 2. 54 to 60. MND. p, 9-10.
51a. I. 4. 7.

the form of a boar, lifted the earth up and set her on the mighty sea. And, resting on the sea like a giant bark, earth did not sink in consequence of the expanse of her frame. Then was created the topography on it.[51b]

This Purāṇa also divides the universe into three regions (lokas)—the upper, middle and nether and fourteen Bhuvanas (worlds) comprised of seven upper worlds, including the earth (being the middle one), and seven traditional Pātālas. To these is added a list of hells also.[51c]

The Mārkaṇḍeya Purāṇa embodies these lines; where golden egg is stated to be the frame-work of the world:

"That egg enclosed all these three worlds, with all that they contain movable and immovable. Meru was born from it, and as the after-birth were born the mountains; the oceans were the fluid contained within that egg which held the great soul. Within that egg was all this world, with the gods and demons and mankind, and the continents and other lands, the mountains and oceans and throng of luminous world."[52]

In the Matsya we read—"After dividing the huge Brahmāṇḍa into two parts, he (स्वयंभू—the self-born) made the heaven and earth, Ākāśa (intermediary space) and the quarters. The upper portion of the divided Brahmāṇḍa formed the heaven, the lower one the earth."[53] "Then were created clouds—lightning."[54]

Chapter 3 of the Brahmāṇḍa Purāṇa (Pūrvabhāga) describes the origin of the entire universe, that is the sun, the

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51b. 1. 4. 45 to 49.

51c. cf earth described in II. Chapters 1 to 4, Pātālas II. 5. Upper regions II. 7, and the hells II. 6.

52. 45. 66-67.
53. II. 31-32.
54. II. 33-34.

moon, stars, planets, earth, atmosphere and the like from the golden embryo.[55]

The Viṣṇu Purāṇa speaks of several incarnations (अवतार)– fish, tortoise, boar and the like.[56] Other Purāṇas also, speaking in terms of incarnations, point to the same gradual evolution of life in the fabric of cosmogony.

From a critical study of the cosmogony of the Purāṇas, it is found that though they incorporate the seedlings of Vedic conceptions, their details resemble more those occurring in the Manusmṛti and in them is perceptible a minor improvement and progressiveness in thoughts and a little scientific systematisation of an a priori furtherance of such a chain. Here we perceive unambiguously a glimpse of the Sāṅkhya philosophy. In addition to the evolutionary theory, they advance the view that gross elements combine into a compact mass, the world-egg (Brahmāṇḍa). And that this universe is encircled from a universal sphere (ब्रह्मकटाह), just as the seedlings of Feronia elephantum

"एतदण्डकटाहेन तिर्यगूर्ध्वमधस्तथा,
कपित्थस्य यथा बीजं सर्वतो वै समावृतम् ॥[57]
"ब्रह्माण्डं संवृतं ह्येतत्कटाहेन समन्ततः ।
कपित्थस्य यथा बीजं कटाहेन सुसंवृतम् ॥[57a]

In this connection it is interesting to note that modern science has also proved the universe to be an entire whole in

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55. In the Brahma Vaivarta Purāṇa there occurs a line "उत्ससर्ज च कोपेन ब्रह्माण्डं गोलके जले (प्रकृतिखण्ड २.५०)". It indicates impetuous velocity of the Brahmāṇḍa, as a whole which resembles one of the facts of modern cosmogony (Physical Basis of Geography-Woolridge & Morgan). Some people say that thc word "अण्ड" implies a nebula.
56. I. 4. 8.
57. Brahma Purāṇa 23. 22.
57a. Skanda Purāṇa, Maheśvara Khaṇḍa, Chap. 39, Śloka 40.

which all individual parts, phenomena and processess are integrally connected with each other. This concordance of Indian thoughts with modern science is really a praiseworthy aspect of the former and testifies to the genius of the indigenous people of no mean order.

The concept of several golden eggs and several "fourteen Bhuvanas" which has been spoken of in the Liṅga Purāṇa (and vide footnote 49) and touched upon here on page 13, does not appear to be an innovation, for in the Paingī Upaniṣad, prior to this Purāṇa, were already referred to several Brahmāṇḍas (macrocosms or universes). Again it fully tallies with the concept of modern astronomy that in space there is not only one solar system (namely of ours), but there are several solar systems. It is all the more important to note that the plurality of the sun is also referred to in the Ṛgveda,[58] the Taittirīya Sanhitā[59] and the Brāhmaṇas.

The notion of bubbles spoken to be the primeval cause of the universe in the Skanda Purāṇa compares favourably partially with the modern Planetesimal theory and partially with the nebular theory of cosmogony.[60]

Astronomical Treatises

The Chapter XII of the Sūryasiddhānta (c. 3rd. Century or 5th. Century A. D.) designated as भूगोलवर्णनम् deals in the opening verses with the cosmogony and Geography. The chapter clearly evidences that those people had quite definite idea of the connotation and denotation of the term "Geography" which included cosmogony also in it. Thus the connotation and denotation of the term Geography were even in very ancient days in India almost the same as are now-a-days (vide Envoi at the end).

Almost all the treatises which are properly astronomical, and not exclusively mathematical, have two separate

58. IX. 114. 3.

59. I. 5. 4. 4. and VII. 3. 4. 1.

60. Cf Wooldridge and Morgan (Physical Basis of Geography) Chapter I.

sections—गणिताध्याय and गोलाध्याय or गणितपाद and गोलपाद Generally every गोलाध्याय of such tracts embodies something of cosmogony or cosmology in brief.

In the abovementioned chapter of the Sūryasiddhānt inverses 12 to 28 are described the processes of creation. These verses purport to say that from the primeval being originated the waters, in it the golden embryo. Then first originated the sun (सवितृ)[61]. He created time and years. Then for creation, the lustrous one created Brahmā. The latter made the moon, our sun, the sky, atmosphere, fire, waters and the earth respectively. Then were made the five elements. Afterwards came into being the Zodaic, asterisms, the moving and immoving and gods. Then he classified stars, planets, the earth, universe, gods, human beings and the siddhas.

The following verses[62] further assert that this Brahmāṇda is hollow, universe exists in the form of curved or arched surface consisting of earth, sky and the like; it has the form of a sphere, like a receptacle made of a pair of caldrons (कटाह). A circle within the Brahmāṇda is styled the orbit of the ether (व्योमन्), within that takes place the revolution of the asterisms (भा); and likewise in order one below the other revolve saturn, jupitor, mars, the sun, venus, mercury, moon; below in succession are the regions of the perfected (सिद्ध), the possessor of knowledge (विद्याधर) and the clouds.

The other siddhāntas[63] also agree in general features with the above description of the Sūryasiddhānta. Varāhamihira[64] also was no exception to the age old traditions.

Thus in the scientific dissection of the cosmogony and cosmology profounded in the Siddhānta treatises it would be

61. Compare it with the ideas of the Praśna Upaniṣad given on p. 8 of this monograph.
62. XII. 29-30-31.
63. Somasiddhānta (between 500 to 900 A. D.) Golādhyāya -25 and the like.
64. Vṛhatsanhitā, Chapter I, verse 6.

found that they could neither substantially add to nor improve upon those of the anterior literature and the Pauranikas (compilers or authors of traditional works or history). Naturally in the Siddhāntas also which are or should be deemed as exclusively scientific works we come across no small amount of the mythical or unscientific, at least appearing so to the modern stage of our knowledge, hypotheses and theories.

Vāstugrantha (Architectural treatises)

Sometimes in the architectural treatises also we have a separate chapter on cosmogony. The Samarāṅgaṇa-sūtradhāra* by king Bhoja (1000 A. D.) deserves special mention in this connection. Its fourth chapter styled as महदादिसर्गाध्याय furnishes good account of creation of universe, stars, planets, our earth and different sorts of life in various heavenly, earthly and nether regions.

Referring to the legend of the birth of Brahmā (the creator) from the lotus, the chapter passes on to state, on the lines of Sāṅkhya philosophy, that creation started from the Mahat (the great). Prior to that it has acknowledged a process of annihilation also preceding the creation.

After the Mahat and elements were created, gods, demons and others, the sun, the moon, the asterism, stars, planets, clouds, earth, nether worlds and four types of beings (viviparous, oviparous, plant life and sweat-produced) came into existence in the given order.

The most conspicuous phase of the cosmogony of the Samarāṅgaṇasūtradhāra is that it embodies not one, but several traditions, perhaps Bhoja incorporated what he deemed most eclectic. Secondly he has totally omitted every reference to golden-embryo. Thirdly, perhaps he has attempted to add something original or independent in details, specially facts about the origin of the earth and its geomorphological contents which would be discussed at its proper place of this dissertation (Chapter III).

* Also Aparājitapṛcchā Sūtra 3.

The *Yogavāśiṣṭha*, a philosophic-cum-literary work of the seventh or eighth century, provides some scientifically interesting information on the topic under discussion.

It declares that there are numerous universes and suns in the space[64a] and that the former resemble bubbles.[64b] These universe bubbles come into existence and die out in a period of every Kalpa (of 432 crores years and which is just like a moment) in the vast ocean of time.[65] The shape of a Brahmāṇda is further said to be that of a walnut shell.[66] The ultimate and the largest macrocosm which embodies all the smaller ones is also stated to be of the shape of a sphere which is divided into two hemisphere.[67] All the universe or the entire macrocosm in its final dimensions is an electric phenomenon appearing like a flash of lightning in the Time-cloud.[68]

This concept has already been discussed with reference to the Ṛgveda in the preceding pages.

Thus presenting the most salient features of the cosmogony and cosmology as embodied in the most important relevant works of the Brahmanic or Sanskrit literature, now we pass on to Jain system of speculation and investigation of these topics.

Jain Literature

According to the Jainas, the universe is eternal and it has no end and as such they have no cosmogony at all. So far as their cosmology is concerned, it is different from that given in the Brahmanic literature and traditions. The

64a. Utpatti-Prakaraṇa. Sargas 30 and 85.

64b. Ibid. 30. 4.

65. Nirvāṇa-Prakaraṇa the first half 7. 58.

66. Utpatti-Prakaraṇa 29.56.

67. Nirvana Prakaraṇa, Uttarārdha, 127. 20.

68. ..... संतप्ता सृष्टि-विद्युत: ।
कालमेघे स्फुरन्त्येताश्चित्प्रकाश-वनोद्यमा: ॥
(Nirvāṇa Prakaraṇa Pūrvārdha. 7. 60).

Jainas have divided the universe into two parts—Lokākāśa and Alokā-kāśa. The Lokākāśa is permeated by the two substances Dharma (having the property of ether), and Adharma (Pudgal or soul and matter). It is the media of motion and rest of every substance and indispensable condition of presence of all existing things. The Alokākāśa is an absolute void and altogether impenetrable to anything either matter or souls.

The Jainas have imagined the world (लोक) to be just like a spindle resting on half of another, or as they describe it, three cups of which the lowest is inverted, and uppermost meets at its circumference the middle one. They have also compared the world (लोक) to a woman with her arms akimbo.[69] According to them the disk of the earth is in the lower part of the middle, below the earth or the nether regions or hells and above it upper regions. In describing the upper region, middle region and lower region, they have compared them separately to several other fantastic figures.[70]

In their cosmology the entire world (लोक) rests on a big layer of thick watery wind (घनोदधिवातवलय), this on one of thick wind (घनवातवलय), and this again on one of thin or rarified wind (तनुवातवलय).[71] Colour of these is blue, light bluish white and undefinable respectively.[72] Modern space research also concurs with this view of the Jainas. There are given various measures also in this connection.

The Jain thinkers have given a definite figure for the volume of the universe—239 cubic Rajjus according to the Śvetāmbaras and 347 cubic Rajjus according to the Digambaras. Through long calculation of the measure Rajju in

69. Encyclopædia of Religion and Ethics by J. A. Hastings 1911, Vol. IV, Cosmogony and Cosmology (Jain)
70. Tattvārthāvārtika by Akalaṅkadeva with text edited by Prof. Mahendra K. Jain, 1—20 p. 317.
71. Ibid and Tattvārthādhigamasūtra, Sūtra 1 of Chapter III.
72. Ibid Sūtras 7—8 and their commentary.

terms of miles and verification of volume given by the Jainas, Prof. G. R. Jain[72a] has tried to show that there is a resemblance or even approximation between the volume of the universe given by Prof. A. Einstein and the Jainas.

The Sūryaprajñapti knew that the earth and universe are circular or something of sphere-shaped. The commentator says "तन्मतेन हि भूरियं गोलाकारा, लोकोऽपिच गोलाकारतया व्यवस्थितः" 'according to him the earth and universe are circular or something of sphere-shaped.'[73]

The Sūryaprajñapti informs us that through every division of time, the chain of destruction and rebirth of suns and moons is operating in the space.[74] This concept together with the fact that the universe never had a beginning and will never have an end is propounded by a section of modern scientists also.[75]

Buddhist Sources.

In the field of cosmogony and cosmology the Buddhists had their own ideas, though at once it is true that they had either borrowed from or were influenced by some of the Brahmanic concepts and traditions.

In the body of Abhidharmaśāstra, there is included a particular treatise named "Prajñapti-Śāstra," which specifically treats of the above-mentioned branches of knowledge. The second section of the Prajñapti-Śāstra which is styled as Loka-prajñapti exclusively deals with cosmology. The Prajñapti Śāstra was written nearly 500 B. C. by Modgalāyana.

72a. Cosmology—Old and New by Prof. G. R. Jain p. 105, 117-18.

73. प्राभृत २, प्राभृतप्राभृत १ पन्ना ४६ (This perhaps forms the foundation of the previous page).

74. प्राभृत १७, च्यवनोपपातौ, सूत्र ८८

75. The Mysterious Universe. p. 181. Most recently, that is, in January, 1960, a Russian scientist B. Maximychev (Head of Astronomy Division Moscow Planetarium) also shares the view. (The Leader 10. 1. 1960).

Buddhists assert that after chaos, when everything is burnt up or "volatilised" and when new creation is to be started, first of all the heaven of Brahmā appears and a class of gods is reborn, then regions or the heavens of other gods come into existence. Next much below them, comes into being the wind circle which has infinite surface. On this wind circle, the cloud of creation pours a sea of golden water. Later when wind sets this sea in motion, originates the water sphere or circle (अप मण्डल) followed by the creation of golden earth.

Afterwards the cloud makes a downpour of gold, precious stones, earth, water, iron and the like, from which in the centre of all this originates earth's physiography.[76]

According to the Buddhists, space is infinite and it contains infinite number of chiliocosm (चक्रवाल) and macrocosms in every direction. There is another technical term Lokadhātu, which also signifies a big universe. Small universes go to combine into bigger systems of thousand[77] or million ones.[78]

The belief of cosmic multiplications is independent and probably prior to the chiliocosmic conception as is proved by various Buddhist scriptures.[79] It is also said that in creation an infinite number of world germs play the productive role, from each is born a universe (great chiliocosm).[80]

The Aṅguttara and Lalitavistara speak of thousands and crores of mountains, continents and oceans in other small

76. The above account is mostly based on cosmogony and cosmology (Buddhist) Encyclopædia of religion and ethics Vol. IV, p. 130. (1911)
77. Aṅguttara Nikāya Part I, p. 227, Part V p 59.
78. Lalitavistara, p. 149-150
79. Dīghnikāya II, p. 139 and Jatakas (vide Encyclopædia of Religion and ethics, Vol. IV, p. 137).
80. Vide Encyclopædia of Religion and ethics Vol IV, p.137.

and big universes[81] (stars and planets). Now we can very pertinently ask the question whether they knew or guessed that on planets or heavenly bodies, there are these topographic features present ?

In the Mahāvastu also we came across an account of creation of the world, but there is nothing particular or additional in it.[82]

An analysis of the above account of cosmogony and cosmology would reveal that it contains remarkable philosophy and depth of thought. Annihilation, new creation and outlines of the origin of earth's physiography are the borrowed ideas of the Brahmanic tradition.

So far as concept of numerous universes is concerned precursor Paingī Upaniṣad and successor Liṅga Purāṇa and Yoga Vāśiṣṭha can be easily compared with that of the Buddhists discussed above.

Shape and Size of Universe—Old and New Concepts Compared

As in modern times we have different schools regarding shape and size of the Universe, so was the case in days of yore in India. But as shall be evident from the sequel, generally most of the important pristine Indian schools concur with those of modern science.

It has already been examined on page 6 how the description of the universe given in the Śatapathabrāhmaṇa favourably compares with that of soap-bubble surmised by Sir James Jeans. Further Brahma Purāṇa, Skanda Purāṇa[83] and Sūryasiddhānta[84] referring to the universe to be of the form of (ब्रह्माण्डकटाह) a sphere or two hemispheres joined anticipated J. Jeans. The Jaina treatise Sūryaprajñapti[85] has also fallen in the same time. Later astronomers, namely,

81. Anguttara, Part I, p. 227, Part V, p. 59, Lalitavistara p. 149.
82. The Mahāvastu, Eng. Trans. by J. J. Jones, Part I, p. 285.
83. Anterior page 14-16.
84. Anterior page 17-18.
85. Anterior p. 22.

Brahmagupta (628 A. D.) Śri-Pati (in Siddhāntaśekhara—1039 A. D.) and Bhāskarācārya[86] (1150 A. D.) unequivocally share the same view.

It is really surprising that the Yogavāśiṣṭha referring to the form of universes actually uses the term "bubbles" in the comparison and in its opinion the shape of ultimate Brahmāṇda (universe) resembles the shell of a walnut.[87]

A word of note, since the concept of soap-bubble propounded by Jeans is explained by the theory of relativity, the above comparison of old and new thoughts should not be carried too far. It is merely the simplest possible similarity between the two ideas of two different ages separated by large haitus, even if it is admitted that the ancient Indians anticipated some ideas of the theory of relativity in visualising the interwoven structure of time and space.

Large number of universes, systems of universes and numerous suns and moons in the space are some of the concepts of Brahmanic lores and treatises of the Jainas and Buddhists which are fully in conformity with modern science.

So far as size and dimension of the universe are concerned, modern scientists are divided in two schools—one maintains that universe is finite but expanding, while the other holds that it (including space) is infinite.[88]

Indian astronomers (Siddhāntakaras) have also made quite scientific and logical speculation about the size and dimension of the universe. Brahmagupta[89] Śripati[90] and Bhaskarācārya[91] have given the diameter of the universe

86. For all the three Cf. Siddhāntaśiromaṇi Kakṣādhyāya in the Madhyamādhikāra.
87. Anterior p. 20.
88. The mysterious universe, p. 80, 168, 169.
89. Quoted in the footnote of Siddhāntaśiromaṇi, Madhyamādhikāra kakṣādhyāya.
90. Siddhāntaśekhara, p. 95. (Madhyamādhyāya, verse 62).
91. Siddhāntaśiromaṇi. Same as above footnote 89.

to be 18712069200000000 Yojanas, which indicates that they had some conception of finiteness of universe.

But Bhāskarācārya appears to be vascilating between the above mentioned two schools of modern science. He says[92] :

ब्रह्माण्डमेतन्मितमस्तु नो वा
कल्पे ग्रहः क्रामति योजनानि
यावन्ति पूर्वैरिह तत्प्रमाणं
प्रोक्तं खकक्षारव्यमिदं मतं नः।

"I do not bother whether this universe is finite of infinite. But it is my opinion that the distance traversed by a planet (or planets) in Kalpa[93] has been designated by predecessors as circumference of the sky or universe."

Though finally he declares that he has not given or surmised the dimension of the universe for two reasons : प्रमाणशून्यत्वात् प्रयोजनाभावाच्चास्माभि ब्रह्माण्ड न कथितम्[94] firstly because it is dimensionless and secondly that there is no necessity for it. Now this raises the question whether he had finally settled on the concept of infiniteness of the universe. And whether in the above quoted verse 3 is embodied the concept of finite, but expanding universe of Einstein[95], when we know that "perpetual motion machines are impossible"[96] and concurrently ask to ourselves if ancient Indians knew or imagined the universe to be a sort of "moving machine".

Jainas appear to have entertained the notion of finiteness of space[97] whereas we need not repeat the details of Buddhist speculation that universe is infinite.[98]

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92. मध्यमाधिकार, कक्षाध्याय, श्लोक ३
93. For the measure of Kalpa, its anterior pages.
94. Siddhāntaśiromaṇi, Bhuvankośa, Golādhyāya.
95. The mysterious universe, p. 81.
96. Ibid. p. 181.
97. Anterior. p. 21-22.
98. Anterior. p. 23-24.

In this study of Indian cosmogony and cosmology, it must be remembered that the ancient Indian writers of different branches of literature (including sciences) while treating of this subject, have intermixed the mythical, metaphysics, philosophy, astronomy and geography. And pursuing this methodology of treatment in discussing and presenting the concrete realities, matters and scientific facts of experimental realm of corporal world, they inadvertently and automatically entered the bounds of subtle subjective thinking, transcendental conceptions and legendary explanations where the tentacles of their knowledge and logic failed. But whatever be the case, we can chaff out the relevant and useful material from such type of repertories of information and speculation.

Another notable point is that the subjects of cosmogony and cosmology were unequivocally incorporated in the monographs and treatises on Geography proper, or even sections of various esteemed tomes which dwelt on भूगोलवर्णनम् (Geographic descriptions), भुवनकोश (World system) or क्षितिनिवेश (world arrangement) almost invariably included some thoughts and details of cosmogony and cosmology as an extremely important accidents of the foregoing three topics. And most probably later on (of course before or round about 1200 A. D.), there existed a long established convention of writing separate independent self-contained dissertation on cosmogony and cosmology exclusively as definite branches of Geography as is proved by various later manuscript works like भूगोलपुराणम् (C. 14th. or 15th. Century), भूगोलवर्णनम् (C. 14 or 15th. Century), भूगोलोत्पत्ति and वसुधाजन्मकथनम्, which the present author has come across and examined during the course of his researches in various manuscript-libraries and private collections.

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Development of Geographic Knowledge in Ancient India

CHAPTER II

Astronomical and Mathematical Geography :—

Time

Space

Earth—gravitation, its size, shape, motion, causation of day and night, and planetary relations.

Eclipse—definition, mathematical theory.

Concepts of graticules.

Computation of latitudes and longitudes.

CHAPTER II

ASTRONOMICAL AND MATHEMATICAL GEOGRAPHY

The Vedic Literature

The Ṛgveda furnishes considerable information about the astronomical Geography. Astronomical observations and their correlation with earthly phenomena had started earlier than the Ṛgveda. H. H. Wilson says.[1] "The Angirasas, as we have before seen, appear to have been among the ancient astronomers, the inventors of the lunar asterism (नक्षत्र)". The Ṛgvedic Aryans knew that the sun was the distributor of time and space.[2] They had also clear-cut idea of one and only one sun illuminating our earth.[3] The verse III. 31. 17 says that the cause of the night and the day is the sun. In I. 164. 13 the Ayana (solstice),[4] season, month, fortnight, day, night and hour are indicated as the seven portions of the year.[5] Explaining I. 155. 6 Prof. Wilson observes (in notes) about the reference "ninety four" "Ninety and four periodical revolutions—Viṣṇu is here identified with time comprising ninety-four periods—the year, two solstices, five seasons, twelve months, twenty four half-months, thirty days, eight watches and twelve zodaic signs." Commenting on I.164.11 Sāyaṇa also says that twelve zodaic signs were known to the Ṛgveda.[6] M. Mollien confirms Sāyaṇa's statement. Sāyana's commentary on X.56.5 further details the Ṛgvedic astronomical knowledge "having sub-

1. See vol. VI, p. 354.
2. I. 95.3.
3. Vālakhilya, VIII. 10.2; Ṛksanhitā VIII. 58.2.
4. VI. 32.5 refers to winter solstice.
5. Vol. II, Wilson, notes, p. 268.
6. M. Mollien—Memoirs de l' Academic des inscriptions, premiere serie, Vol. 3.

divided the planets, lunar asterisms etc." The hymn I.25.8 shows the concurrent uses of lunar and solar years. This, II. 40.3 and I. 164.15 also point to the intercalary month. On the basis of VII.103.9 Jacobi says that in the Vedic times the year began in rainy season, while some recognise the beginning of year with Hemanta,[7] but it does not appear to be quite appropriate. From the hymn X.85.13 it can be inferred that the Ṛgvedic Aryans also paid attention to the motion of the moon and I.84.15 most unequivocally expresses that the moon is illuminated only by the sun's light.

In I.24.10 we find a mention of the great Bear or Saptarṣimaṇḍala. The Ṛgveda also recognises fourteen Bhuvanas,[8] six lokas,[9] and seven lokas.[10]

The Ṛgvedic Aryans definitely knew about the occurence of eclipses.[11] Ludwig goes to the length of saying that they even knew the theory of eclipses, but Whitney has contradicted the statement.[12]

Mutual attraction of heavenly bodies and gravitation are referred to in X.85.1 and X.149.1. The sky is said to be rafterless[13] and so on and that it never falls is a source of great wonder.[14]

There are several other hymns which refer to some astronomical facts, but they are not quite clear to us—the full and real meaning of those references are not known to us, for example, X.85.16.

"We have also knowledge of.....computation of the divisions of time to a minute extent.....".[15]

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7. VI. 10.7.
8. X. 114.7
9. I. 164.6.
10. VII. 18.24.
11. V. 40.5 to 9.
12. Vedic Index, Vol. II-p. 466.
13. II. 15.2.
14. V. 29.4 and VI. 17.7.
15. Vol. II, Introduction, p. XI-Wilson; and X. 189.3.

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These Aryans were well acquainted with the sphericity of various heavenly bodies.[16]

Spherical concept of the earth is expressed in III. 55. 20 and X. 89. 4. I. 33. 8. unambiguously asserts the circularity of the earth and gradual arrival of the sun's rays on it as shown in IV. 53.3 can only be true, if it is accepted that here the earth is presumed to be sperical. Of course, this latter meaning is derived, if we explain "निवेशयन् प्रसुवन्नक्तु-भिर्जगत" in the way in which Jyotiṣāchārya Pt. Girija Prasad Dvivedi, the Hindi commentator of the Siddhānta Śiromaṇi, has done. It must be borne in mind that this explanation of निवेशयन् as gradual arrival is fully justified by Sanskrit Lexicons.[17]

In several verses the earth is said to have a past circular motion, for example V.30.8.

Like the Ṛgveda,[18] the Taittirīya Sanhitā[19] also seems to say that the sun is the pivotal point or centre of all. Most probably these verses refer to some conception of heliocentric theory.[20] In XX. 34. 2 the Atharvaveda appears to speak of the motion of the earth.

The Taittirīya Sanhitā[21] also points symbolically to the force of attraction operating in the sky. In it the infinite or force of boundlessness (Aditi) is said to be the "prop of the sky, supporter of the earth, ruling this world."

The above Sanhitā informs that ".....the night is the form of the day."[22] At another place it asserts[23] ".....

16. Of the sun, moon and so on, Ṛgveda I. 164. 13-14 (सूर्यस्यचक्षू) vide foot note 27.
17. Śaṅkara Bālakṛṣṇa Dīkṣita also derives the same meaning of these verses—Hindi Translation of his Bhāratīya Jyotiṣa Śāstra, p. 31 .
18. I. 164. 2 and I. 164. 14.
19. III. 4. 11.
20. Bhāratīya Jyotiṣa, S. B. Diksita, (Hindi Trans.) p. 28.
21. IV. 4. 12. 5. (Keith, p. 353).
22. III. 3. 4. 1. (Keith).
23. VI. 5. 4. 1—2,

Yonder sun rises turned to all people; therefore each one thinks "Towards me hath it risen." Little doubt can be entertained that these lines show that those people were acquainted with the true causation of day and night.

In the Sāmveda there is a reference to rainbow.[24] In two allusions we learn about the sun's meridian.[25] A clearer assertion than Ṛgveda of the sphericity of the earth is found in the Śuklayajurveda in the following line :—

मातवे पुत्रं पृथिवी पुरीष्यमग्नि स्वे योनावभारुखा ।[26]

Śatapathabrāhmaṇa (C. 2000 B. C.) also unmistakably supports the concept of sphericity of the earth thus: तस्मादेष आभ्यां लोकाभ्यां परिगृहीतः परिमण्डले भवतः परिमण्डलौ ह्येतौ लोकौ—they are round or spherical for these two worlds are spherical."[27] Later on the two worlds are explained to be the heaven and earth,[28] and since the heaven is easily recognisible to be spherical, earth can also be imagined to be the same.

Again SB says that "worlds are fastened to the sun by means of quarters."[29] From this we can easily infer the knowledge of the force of attraction and some conception of heliocentric theory. To some extent it is a better statement of the force of attraction than that occuring in the Ṛgveda.[30]

The Aitareya Brāhmaṇa (earlier than 2000 B. C.) also proves that the ancient Aryans possessed the knowledge of the rotundity of the earth and true causation of day and night. Sāyaṇa gives the same interpretation to the particular passage embodying this fact, which is translated by Keith thus—"The (sun) never really sets or rises. In that they think of him "He is setting verily having reached the end

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24. IV. 4. 9.
25. XII. 11, and XIII. 5.
26. XII. 61.
27. SB. VI. 7. 1. 26.
28. Ibid VI. 7. 3. 2.
29. SB. VI. 7. 1. 17. Part III, p. 269.
30. Cf. Anterior p. 32.

of the day, he inverts himself; thus he makes evening, day above. Again in the that they think of him 'he is rising in the morning,' verily having the end of night he inverts himself; thus he makes day below, night. He never sets; indeed he never sets, union with him and identity" of form and world he attains who knows thus."[31]

The Gopathabrāhmaṇa (belonging to the Atharvaveda) corroborates the same thing—"That very sun never sets or rises. Then those who say that he sets in the west (are incorrect), because actually then the sun, after reaching the end of the day, inverts himself....." "That very (sun) never sets or rises. Then those who hold that he rises in the east, (are wrong), for actually then the sun, after reaching the end of the night inverts himself....."[32]

Force of gravitation is most accurately expressed thus:—पृथिव्यामाकाश: प्रतिष्ठित:। आकाशे पृथिवी प्रतिष्ठिता[33] "The ether or sky rests on earth, the earth rests on ether or sky." This is perhaps the best enunciation of the force of gravity during the whole period of Vedic Literature.

The Gopathabrāhmaṇa expresses a chain of similar ideas in a little unscientific way, "भूमिरप्सु प्रतिष्ठिता.....आपो ज्योतिषि प्रतिष्ठिता, ज्योतिर्वायौ प्रतिष्ठितं, वायुराकाशे प्रतिष्ठित:" "The earth rests on water (void), Water (void) on heavenly bodies, and heavenly bodies on atmosphere, and atmosphere on the ether or sky."[34]

The same force of gravitation is spoken of in the Maitrāyaṇa Upaniṣad thus "व्रश्चनं वातरज्जूनां" ".....the cutting of wide ropes (that holds the stars in their place)."[35]

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31. III. 44
32. IV. 10. compare this and the above with the anterior pp. 32-33.
33. Taittirīya Upaniṣad (C. 1000 B. C.) III. 9.
34. G. B. I. 38.
35. I. 4. The Principal Upaniṣads, Radhakrishnan p. 797.

The Vedāṅga Jyotiṣa (Rg. and Yajuh, C. 1200 B. C.)[36]

It is a treatise of 36 or 44 verses primarily on astronomy, but furnishes some information on astronomical geography also. It outlines and gives the time of winter and summer solstices (दक्षिणायन and उत्तरायण) describes the method of calculation of equinoxes (विषुव) and gives various facts regarding the motion of the sun, the moon and other stars, unit of time—(i) अहोरात्र (day and night), (ii) Lunar month; (iii) Year; (iv) Yuga of five years; solar year; and calculation of intercalary month and the length of the day.

The verse (8) which fixes the length of the shortest and longest day of the year says:

"The increase of the day and decrease of the night during the northern progress of the sun is one Prastha of water; the reverse case during the southern progress of period of six Muhūrtas is the result during one progress."

In his paper[37] on the Vedāṅga Jyotiṣa, Dr. J. Thibeaut observes regarding this discovery or scientific originality of our forgotten pristine geniuses, "The estimation of the longest at eighteen muhūrtas and of the shortest day at twelve muhūrtas, and the simple rule for finding the length of any day during the year appear to have generally prevailed in India before the influence of Greek science began to make itself felt."

Verses 28 to 31 prove that the author of the Vedāṅga Jyotiṣa was acquainted with solar and siderial year both and easily distinguished between them.

The Epic Age

Although the Rāmāyaṇa refers to solar and lunar eclipses several times, still everywhere the cause of eclipse is said to be Rāhu and Ketu.[38]

36. Edited and English Translation by R. Shamasastry.
37. Vedāṅga Jyotiṣa by Dr. G. Thibeaut, J. R. A. S. Bengal, Vol. 46, 1877, p. 421.
38. I. 55. 9, II. 12. 63, III. 66. 10, VI. 4. 42 and others.

In II. 41. 10-11 several of the planets of the solar system (mars, jupiter, mercury, moon and "other planets") are referred to. Venus was also known as is indicated by VI. 4. 48. In this very verse is mentioned the pole star. At another place Rāma or the supreme being is said to be the support of the earth having mountains. It would not be unreasonable if this is taken to imply to a certain extent the gravitational force as the sole support of the earth.

In IV. 43. 54 (सतु देशो विसूर्योऽपि तस्य भासा प्रकाशते) Dr. B. N. Seal traces a reference to the Aurora Borealis, which appears to be quite reasonable and plausible.[38a]

The Mahābhārata mentions various facts of astronomical geography which were known from the past. It informs that its author knew that eclipses occur at the end of the first fortnight and on the day of the full-moon.[39] The large Indian units of Time, namely Satayuga or Kṛtayuga, Tretā, Dvāpara, Kaliyuga had become prevalent by this time.[40] In the Mahābhārata also, like the Vedāṅga Jyotiṣa, at a particular place a Yuga is defined to be of five years.[41] The tome gives the dimensions of the earth, the sun, the moon and mentions planets, stars and constellations.[42] According to it the number of planets is five or seven. Dr. Gorakh Prasad has tried to show that those Indians knew the true theory of eclipses.[43] People knew that heavenly bodies are spherical in shape—परिमण्डलो महाराज स्वर्भानुः श्रूयते ग्रहः[44] "O King it is heard by us that the planet स्वर्भानु is a globe."

38a. Vide the Rāmāyaṇa IV.43.35-36 and "Positive Sciences of the Hindus" by Dr. B. N. Seal.

39. Sabhāparva 79. 19 vide Bhāratīya Jyotiṣa Kā Itihāsa, Gorakh Prasad p. 162; Bhīṣma-parva II. 23 (MND) Bhīṣmaparva, III. 32 (or MND III. 28, p. 4)

40. Ādiparva I. 65 (or 66).

41. Ādi Parva, 124. 22.

42. Ādiparva, I. 65.

43. Bhāratīya Jyotiṣa Kā Itihāsa, p. 76.

44. VI. 12. 4.

The Harivanśa, a suppliment to the Mahābhārata, recognised the fact that one planet may be the progeny of the other—

तस्य मण्डलमध्यात्तु निःसृतं सोम-मण्डलम् ।
स सनातनाजो ब्रह्मा सौम्यं सोमत्वमन्वगात् ।।

"From that sphere of the sun originated the sphere of the moon, that eternal moon, being the Brahmā, is the king of the Brāhmaṇas."[45]

In the Vyāsa Bhāṣya (C. beginning of Christian era) of the Pātañjali Yogasūtra also we have got some scattered traditional facts of astronomical geography.[46] Vedānta Sūtra (C. beginning of Christian era) tells us that the ether is the support of the two worlds.[47] In the Vaiśeṣika Sūtra (600 or 700 B. C.) force of gravitation is spoken of thus in the clearest terms—गुरुत्वप्रयत्नसंयोगानामुत्प्रेक्षणम्[48], and संस्काराभावे गुरुत्वात्पतनम्[49] (In the absence of propulsive energy generated by action, falling (results) from gravity."

The Pauranic Age

Facts of astronomical geography are scattered in almost all the Puraṇas. Not infrequently they contain several sections or chapters on this particular topic. In the Part II of the Viṣṇudharmottara occurs a separate siddhānta section in prose which is designated as "Paitāmah Siddhānta."

Though the aforesaid sections and chapters of the Puraṇas contain a lot of mythical, legendary or imaginary material, still in them we come across considerable scientific information which is quite accurate.

The Puraṇas mention lunar and solar eclipses several times, but perhaps they have never given their true mathematical theory. The Viṣṇudharmottara, however, appears

45. III. 16. 28.
46. Section III, Sūtra 26 (Vyāsa Bhāṣya) p. 189.
47. I. 3. 16.
48. I. I. 29.
49. 5. I. 8.

to make a correct approach to some extent to the true theory of eclipses. It says[50]—

.....पर्वकाले च संप्राप्ते चन्द्रार्कौ छादयिष्यसि ॥४२॥
तमोमूर्तिरदृश्यश्च विपरीतं चरिष्यसि ।
भूमिच्छायागतश्चन्द्रं चन्द्रगोऽर्कं च दानवः ॥४३॥

"(The demon) will obscure the moon and the sun at the end of the dark fortnight and full moon (पर्वकाले). Entering the shadow of the earth and moon, the swarthy-figured concealed demon will bring adversity to the moon and the sun respectively."

Chapter 8 of the Part II of the Viṣṇu Purāṇa recognises the "Heliocentricism."[51] Mr. Fitz-Edward Hall[52] has agreed with this interpretation, though Dr. G. Thibaut contends it.[53] The Bhāgvat also appears to be acquainted with the heliocentric theory.[54]

How heavenly bodies are moving supportless in the sky through the gravitational force is concisely expressed thus with a very apt simile in the Śiva Purāṇa "जगन्ति नित्यं परितो भ्रमन्ति यत्सन्निधे चुम्बकलोहवत्"[55] —around which heavenly bodies are moving in the same way as iron pieces around a magnet.

The following verse of the Vāyu-Purāṇa evidences that its author either knew or guessed that on other planets or heavenly bodies also there are oceans, mountains and the like —चन्द्रसूर्य प्रभालोको ग्रहनक्षत्रमण्डितः । नदीभिश्चसमुद्रैश्च पर्वतैश्च समावृतः[56] (The universe illuminated by the moon and the

50. Chapter 42.
51. अंश २, अध्याय ८ particularly मैत्रेय भगवान् भानुज्योतिषां चक्र-संयुतः ।१०।
52. Wilson's Viṣṇu Purāṇa, Vol. II, p. 242.
53. On the Sūryaprajñapti by Dr. G. Thibaut, in the J. R. A. S. Bengal, Vol. XLIX, 1880 pp. (107—127).
54. V. 20. 43 and V. 21. 3; also of Liṅga 54. 5.
55. संहिता २, खण्ड १, अ० १, श्लोक ३.
56. The Vāyu-Purāṇa—IX. 112.

sun, decked with planets and stars and encircled by rivers, oceans and mountains.")

Quite a number of Purāṇas speaks of the sphericity of the earth and true causation of day and night and different times in clocks at a particular moment at different longitueds. The Viṣṇu Purāṇa states "O Maitreya, while in one insular continent the sun shines in midday, in the opposite dvipas it will be midnight, rising and setting thus take place at all seasons and are always opposed in the different cardinals, and in intermediate points of the horizon. Whenever the sun is visible he is said to rise there and whenever he disappears from view, he is said to be set. In sooth, there is neither rising, nor setting of the sun; for he always exists; the appearance and disappearance of the sun are merely called rising and setting."[57]

The Brahmāṅda Purāṇa fortifies the same thing thus[58]—

विदूरभावादर्कस्य भूमिलेखावृतस्य च ॥५१॥
लीयन्ते रश्मयो यस्मात्तेन रात्रौ न दृश्यते..... ॥५२॥

"The sun, being at a large distance, and shadowed by the earth, ...is not seen in the night."

Chapter 54 of the Vṛhannārdīya Puraṇa provides some quite accurate information on Mathematical Geography. It gives the radius of the earth to be 800 Yojanas (or 4000 miles, where one Yojan=5 miles) and its diameter and circumference to be 1600 Yojanas and $1600\sqrt{10}$ or 1600X3.162 Yojanas respectively, whereas it ought to be 1600X3.141.[59]

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57. Anśa 2, Chap. VIII, Verses 11-12-13-14, compare it with Aitareya Brāhmaṇa Anterior, p. 34.
Vide Vāyu Purāṇa 50. 94 to 97 Liṅga Purāṇa, 54. 1 to 11 and Matsya Purāṇa Chapter 124. 27-31. In this connection four towns are mentioned which are situated on 0°, 90°E, 90°W and 180°.

58. Chapter 21 (Pūrvabhāga).

59. .....योजनानि शतान्यष्टौ भूकर्णो द्विगुण: स्मृत: ॥८३॥
तद्वर्गगतो दशगुणात्पदं भूपरिधिर्भवेत् ।
लम्बज्याघ्नस्त्रिजीवाप्त: स्फुटो भूपरिधि: स्वक: ॥८४॥

There in the succeeding line is stated the formula for finding the circumference of any latitude parallel to the equator.[60] Mathematically it is totally correct. It is noteworthy that the wordings of these lines are almost the same as those of verses 58 and 59 of Chapter one of the Sūryasiddhānta and naturally the margin of error in determining the circumference is also the same as that in the latter.

The Viṣṇudharmottara Purāṇa speaks of the prime meridian or 0 degree of longitude passing through Laṇkā and Meru in the north and computation of time east and west to this prime meridian.[61]

Some of the Purāṇas[62] have said that the shape of the earth is that of a lotus. If this lotus were not to be a flat one and had the least idea of a globular shape, it can be said that those schools of particular Purāṇas perhaps assigned a shape to the earth which conforms to the great degree to most recent American conception of pear-like globe.

Like the Vālmīki Rāmāyaṇa[62a], the Viṣṇudharmottara[63] definitely appears to refer to the Aurora Borealis : Here the mention of Ilāvṛta and Meru, which are undoubtedly situated in the northern extreme, makes it all the more certain that the lines speak of the Aurora Borealis.

इलावृतस्तु प्रभया मेरोर्नित्यं प्रकाशते ॥२६॥
न तत्र भ्राजते सूर्यो न चन्द्रो न च तारका ॥२७॥

Astronomical Works.

These are the best sources which deal with the subject of astronomical and mathematical geography very systematically and accurately, though here and there they are interspersed with traditional, legendary fallacious and imaginary information also.

60. Ibid लम्बज्या.....स्वक: ॥८४॥
61. Chapter 168.
62. Bhāgvat V. 16.5, Vāyu Purāṇa-34.44,46;41.86 Vārāha Purāṇa 75. 46.
62a. Anterior p. 37.
63. Khāṇda I, Chapter VII.

It must be conceded beyond any controversy that round about the beginning of Christian era, methodical and scientific siddhānta literature had come into existence, and most probably there existed good siddhāntas at least a few centuries before Christ and much of what they contained was evolved or discovered independently by the Indians without any external influence. In the heyday of Indian astronomy, that is, from 3rd century A. D. to 1200 A. D., the siddhānta literature tremendously influenced the countries west of India.

Another notable point is that throughout this period 300 A. D. to 1200 A. D., we perceive a general tendency and aspiration, full of endeavours, in the authors of Siddhāntas to improve upon the predecessors and add something new.

The Sūryasiddhānta[64] gives the diameter of the earth to be 1600 Yojanas and tells how to find its circumference by multiplying the diameter with $\sqrt{10}$ or 3.162. Here value of π is only roughly taken, though the Sūryasiddhānta knew its very accurate value as is revealed by Chapter II. In the succeeding line of the same verse[65] is explained the method of determining the circumference of any latitude parallel to the equator. Verse 61 enumerates the names of places lying on the Hindu Prime meridian. Next two verses tell us how to know whether the local place is situated to the east or west of the Prime meridian. From verses 63 and 64 we learn haw to determine the longitude from the difference of local and standard times of immersion and emersion in an eclipse. In the following verse is explained the reckoning of commencement of the day for places lying to the east and west of the Prime Meridian. In Chapter II the force of attraction among the heavenly bodies is thus referred to

तद्वातरश्मिभिर्नद्धा .....(Yoked by the rays or strings of that wind).

64. Chapter I. 58.
65. Chapter I, verse 58.

प्राक्पश्चादपकृष्यते.....॥ २ ॥
प्रवहारव्यो मरुत्तांस्तु स्वोच्चाभिमुखमीरयेत् ।
पूर्वापराकृष्टास्ते गतीर्यान्ति पृथग्विधा ॥ ३ ॥

In the first four verses of the next chapter is explained the method of finding quarters by the shadows cast by a gnomon in the forenoon and afternoon. From verses 13 and 14 we learn how to find the latitude with the help of the shadow of a gnomon and the equinoctical midday sun. The following three verses furnish the rule for finding the sun's Zenith distance at midday and the latitude of the place.

In Chapter IV and V are discussed the theory and mathematics of lunar and solar eclipses respectively. They evidence that the author of the siddhānta was well acquainted with the true causation of eclipses and could make computation regarding them. The chapter IV has also given the linear diameter of the sun and moon to be 6500 and 480 Yojanas respectively. Here the diameter of the sun is much erroneous, but that of the moon is approximately correct. According to the siddhānta the moon's diameter is .33 of that of the earth, whereas modern calculations have proved it to be .27 of that of the earth.

In chapter 12 the gravitational force of the earth is further described thus :

मध्ये समन्तादण्डस्य भूगोलो व्योम्नि तिष्ठति ॥ ३१ ॥
विभ्राणः परमां शक्तिं ब्रह्मणो धारणात्मिकाम् ॥

"Amidst the universal egg in the sky the earthly sphere rests carrying the incomparable power of Brahmā, whose nature is bearing the burden or maintaining equilibrium."

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66. "प्रवहारव्य मरुत् literally implies" wind named Pravaha perhaps for want of a better nomenclature, the unseen attractive force is designated as unseen wind. The term रश्मि "string or rays" used above corroborates this interpretation compare Maitryāyaṇa Upaniṣad Anterior p. 35.

The spherecity of the earth referred to in the term भूगोल in the quotation and the force mentioned above are again beautifully elaborated as follows :—

"Those who reside on the same latitude and similar longitude think that others are below them, as the people of Bhadrāśwa do of those of Ketumala, and the people of Laṅkā do of those of Siddhapur (in each pair the former is situated at the antipodes of the latter), and every where people on this earth think themselves to be above, but the earth actually is a sphere in the space; therefore there is nothing like above or below."[66a]

Later on the equality of day and night on the equator and inequality and increase and decrease of day and night on other latitudes are propounded, followed by a mention of places where (night and day) are of two months, four months and six months in length. This is quite accurately stated.[67]

In the verses 67-68, is stated that when there is sunrise in Bhārata, there is midday in Bhadrāśwa, sunset in Kuru and midnight in Ketumāla.

From verses 80 to 87 we learn the distances of the sun and moon from the earth to be 6, 89, 430 and 51, 5, 66 Yojanas[68] respectively. Here the moon's distance approximates to the modern calculation, but the sun's distance contains a large error.[69] But this much was known to the astronomers (contrary to the Purāṇakāras) that the sun is at a greater distance from the earth than the moon.

Āryabhatta (476 A. D.) was the first and the last astronomer geographer who recognised and acknowledged the movement of the earth. This is clearly proved by the verse 4 (प्राणेनैति कलाभू:) of the Gītikāpāda and verse 9 of the

66a. XII. 49-50-51.

67. XII. 53 to 66.

68. Here a Yojana equals 5 miles.

69. Vide Bhāratīya Jyotiṣa (Hindi Trans) —S. B. Diksita, p. 422—23.

Golapāda[70] of his Āryabhatīya. If we take into account only these two verses, it would lead to the conclusion that the celebrated astronomer was acquainted with both rotation and revolution of our planet. But the verse 10 of the Golapāda has created some doubt in the minds of critics, hence it is generally surmised that he knew only rotation of the earth.

The Gītikāpāda also gives approximately accurate diameters of the earth and moon. The diameter of the sun given here is much erroneous. From this Pāda we learn approximately correct distance of the moon from the earth.

The Golapāda (verse 5) says that the earth, planets and stars are illuminated by the light of the sun, though this statement is incorrect in case of stars. The verse 8 informs of a peculiar fact that the circumference or rotundity of the earth increases and decreases by a Yojana in a day and night of Brahmā respectively. It is all the more interesting coincidence that modern geophysicists also here measured almost the same extremely slow vector increase in the bulge or protruberances of the earth crust. The verse 13 tells us why there is a difference in times of different places situated on the same latitude. From verse 14 can be inferred the relationship of linear and latitudinal distances on the earth.

In the Pañcasiddhāntikā of Varāhamihira we have some such informations which merit special notice at least from the chronological point of view.

Although the Pañcasiddhāntikā is a summary of five older treatises, it appears that its thirteenth chapter desig-

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70. अनुलोमगतिर्नौस्थः पश्यत्यचलं विलोमगं यद्वत् ।
अचलानि भानि तद्वत् समपश्चिमगानि लङ्कायाम् ॥९॥
"As stationary objects on the bank appear to be going in the opposite direction to a man sitting in a boat, so stationary stars seem to be travelling towards West from Lanka (the equator)."

nated as "Trailokyasansthāna" is the original composition of Varāhamihira himself. Its first verse[71] shows that Varāhamihira knew that all stars possess force of attraction and that the earth is supportless in the space encircled by them. In the fourth verse he points to the gravitational force of the earth also. Illumination of the moon and causation of its digits are explained in a more precise and scientific way.[72] "The illuminated part of the moon increases, as its position relative to the sun changes. This happens just in the same way as the western position of a jar becomes more and more illuminated in the afternoon." In the verses 31 to 34 of the same chapter he says that by determining the latitude of a place (thus of two places) by the polestar, we can measure out the dimensions of the whole earth.

The Brahmasphutasiddhānta is one of the most important treatises of Brahmagupta, a brilliant astronomer who flourished in C. 628 A. D. The work contains the same information on mathematical and astronomical geography as has been discussed above. In this connection Chapter I, III, IV, V and XXI are particularly noteworthy. The last one (गोलाध्याय) contains some computation concerning Geography.

The Śiṣyadhivṛdhida by Lallāchārya or Lall (6th. C.A.D.) maintains almost literally the same proposition[73] regarding the stellar attraction and existence of the earth without any concrete support amidst the heavenly bodies as Varāhamihira.[74] Later Lalla informs[75] how there is morning in Laṅkā, noon in Yamakoti, evening in Siddhapur and midnight in Rome at the same time. These four towns are taken to be situated on the equator at gaps of 90° of longitude.

71. "The sphere of the earth made of five elements exists in the cage of stars, just like iron encircled by magnet."
72. Pañcasiddhāntikā XIII. 37.
73. Bhūgolādhyāya verse 2.
74. Anterior p. 45. and the first para of this page.
75. Bhūgolādhyāya, verse 12.

Methods of determination of longitude was also known to him.[76] Lalla was a believer in Geocentric theory.[77]

The Somasiddhānta (between 550 to 950 A.D.) tells[78] us that the earth is of the shape of wood apple (कपित्थ) and it is due to smallness of our size that we see it to be flat like a wheel. The Mahāsiddhānta of Āryabhata II (950 A. D.) believed the earth to be bell-shaped.[79] The Siddhāntaśekhara of Śripati reveals the knowledge of determination of longitude[80] and latitude by the polestar.[81] It repeats several information of the Sūryasiddhānta in bold terms and with new arguments.[82]

Last comes in chronological sequence Bhāskarācārya (1150 A. D.), a most brilliant star of the galaxy of Indian astronomers. His splendid treatise Siddhāntaśiromaṇi is divided into two parts-I-Gaṇitādhyāya and Golādhyāya. Both of them have improved in some way or the other on the past store of knowledge of the subject.

We first take Gaṇitādhyāya. Its chapter Madhyamādhikāra[83] gives the the method of computation of longitude, long itudinal time, beginning and reckoning of day and linear distances on a degree of longitudes. In the Tripraśnādhikāra are described the methods of determination of quarters by the sun and the polestar.

Next comes Golādhyāya. Its second chapter Golaswarūpa poses some very scientific questions on several branches of Geography. In the chapter Bhuvanakośa is emphatically asserted that the earth is spherical and that it is maintaining

76. Praśnādhyāya, verse 16.
77. मिथ्याज्ञानाध्याय, श्लोक ४२.
78. Golādhyāya, verse 33.
79. भुवनकोश प्रश्नोत्तर, श्लोक ५ (Compare it with ultra modern pear-shaped concept to of earth).
80. Chapter II.
81. IV. 122-23.
82. e. g. X. 1.
83. Verse 5-6-7. (Vide Madhyagativāsanā of Golādhyāya).

equilibrium in the space through its gravitational force[84] and refutes the assertion of the Buddhists that it is going down. Later on the diameter, circumference and area of the surface of the earth are given. Here very accurate value (3.1416) of π has been taken. Bhāskarācārya has given the the area of the earth to be $4\pi R^2$ (R = the radius of the earth) which is absolutely correct.

In the Madhyagativāsanā he declares that the earth is stationary and it is really surprising that such an astronomical genius did not even care to consider his predecessor Āryabhatta.[85] Later on solar year has been said to be comprised of 365 days, 15 Ghati, 30 Pala and 22½ Vipala or 365 days 6 hours 12 minutes and .375 seconds[86]. According to modern scientists the solar year is comprised of 365 days 5 hours 48 minutes and 46.0544 seconds.

Then follows the chapter Triprasnavāsanā. It describes the method of knowing the time of sunrise and tells the measure of day at different places and periods. It explains why day and night are equal on the equator. It further discusses the duration and phenomena of day and night beyond 66° of latitude and information that on the poles the duration of day is 6 months. In the last is given the method for determining latitude from the pole star.

During the abovementioned astronomical age, the true theory of eclipses had fully crystalised and computation was improved tremendously.

In completing this survey of the Brāhmaṇic literature, the Yogavāśiṣṭha must also be taken into account. It very

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84. Bhuvanakośa—

आकृष्टशक्तिश्च मही तया यत्
स्वस्थं गुरुस्वाभिमुखं स्वशक्त्या
आकृष्यते तत्पततीव भाति
समे समन्तात् क्व पतत्वियं खे ।

85. Anterior p. 45.

86. Verse 8.

beautifully enunciates the shape and attractive force of the heavenly bodies: "The spherical heavenly bodies possess the inherent material attribute of attracting bodies to wards them, and it is inseparable from them as a gem from the bangle."[87] Further the sphericity and gravity of the earth are couched in most poetic language thus : Just like a corporal child's imaginary play-ball resting in the space, the earth created by the transcendental child exists in the sky (without any concrete support)."[88]

Jain Sources

The Jainas also believed that the earth (मनुष्यलोक) is of the shape of sphere (अतिगोल —ellipse ?)[89]. Later on the same source describes the causation and length of the day and night.[90] In the Jyotirbibhāgaprakaraṇa of the treatise Lokabibhāga are discussed the duration of day and night, intercalary month, equinoxes, the two solstices, digits of moons and the like. The Sūryaprajñapti says that when the length of the day is 18 muhurtas, the area of the earth illuminated is 72000 Yojanas, and when the length of the day is 12 muhurtas, the area of the earth illuminated is 48000 Yojanas.[91] But no reason or detail has been given regarding these fantastic figures.

In several of the Jain works[92] a very fanciful fact is mentioned that our world has two suns and two moons. It is not known how the Jainas evolved this idea. The Sūrya-

87. प्रत्येकस्याण्डगोलस्य स्थितः कण्टकरत्नवत् ।
भूताकृष्टिकरोभावः पार्थिवः स्वस्वभावः ।।
—30.32 Utpattiprakaraṇa.

88. यथा संकल्परचिता शिशोर्व्योमनि तिष्ठति
वीटा चिन्मात्रवालेन कल्पिता भूस्तथाम्बरे ।।२।।
—Nirvāṇa Prakaraṇa, Uttarārdha, Sarga 127.

89. Tiloya-Paṇṇatti IV.6. p. 142.

90. 7. 276—289.

91. The Sūryaprajñapti, Prābhṛta 2, Prābhṛtaprābhṛta 3.

92. E. g. Ibid, Prabhṛta 19, leaf. 272.

prajñapti[93] discusses two theories of eclipses. It reveals that the author of this work was acquainted with the true theory of observation of the sun and moon due to shadowing and there was a section of people which accepted it. But this treatise itself does not subscribe to it and combines the traditional legendary view and true scientific theory and says that eclipses are caused by shadowing of light of the sun and moon by deity named Rāhu.

In the Tattvārthādhigama there is a definite reference to the force of attraction.[93a] It propounds that the universe ultimately rests on the sky which is supportless.

Buddhist Literature

The Divyāvadāna (150 B. C. to 300 A. D.) regarding the existence of the earth in the universe says, "Ānanda this earth rests on water, the latter on air, and the last on space (आकाश) the supportless."[94] Milindapañho, a work of the first century A. D., repeats the same thing.[95] But these statements do not make it clear whether this section of the Buddhists was acquainted with the force of attraction operating in the space. The Kārikās 45-47 of the Abhidharma-Kośa[96] deal with the similar subject and they can be explained in the same way as the above lines of the Divyāvadāna.

The author of the Abhidharmakośa knew that the moon is not self-illuminated, but derives its illumination from the sun.[97] Here it is also stated that the diameter of the sun is larger than that of the moon, but the figures given are absurd.[98]

93. Prābhṛta 20, Sūtra 105.

93a. Chapter 3, Sūtra I.

94. Divyāvadāna, edited by Cowel and Neil, Avadān 17, p. 204. Compare Gopathbrāhmaṇa Anterior pages.

95. The Questions of King Milinda-Trans. T.W.R. Davids III. 5. p. 106.

96. Chapter III (तृतीय कोशस्थान) The Dīghanikāya also has the same opinion 16.3.13 p. 107 (Text).

97. Chapter III. Kārikā 62.

98. Ibid-Kārikā 60.

Later on the same text informs that there is difference in time at different longitudes of the various continents. When there is noon in Jambudvīpa, there is mid-night in Uttar Kuru, evening in Pūrvavideha and sunrise in Avaragodānīya.[99] On this basis of this statement it can be inferred that the author or the Abhidharma knew that the earth was spherical. On the basis of another evidence[100] it can be asserted perhaps with greater positivity that the Buddhists knew round about 300-400 B. C. that the shape of the earth was spherical.

The Abhidharmakośa also tells us that increase and decrease of day and night is caused by the northern and southern shifting of the sun.[101] The Divyāvadāna was also acquainted with this fact. It gives more detail and mentions the Tithies (dates) of the longest and shortest day.[102]

The Jātakas show that the contemporary Buddhists were acquianted with the eclipses, but perhaps did not know their true scientific theory. They have merely encored the old traditional Brahmanic legend that they are caused by the swallowing of the sun and moon by Rāhu.[103] But the Dīghanikāya[104] (500 or 550 B. C) speaks of forecasting

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99. Ibid. Kārikā 62.

100. Eng. Trans. of the Jātakas edited by Cowel (Vol. III, No. 427 गिज्झ जातक)

101. Abhidharma-kośa, III. 62.

102. Divyāvadāna, Avadāna 33. p. 642.

"एवं विपरिवर्तमाने लोकनक्षेत्रेषु प्रतिभक्तेषु कति रात्रिन्दिवसानि भवन्ति । कथं ह्रासः वृद्धिश्च । तद् उच्यते । हेमन्तानां द्वितीयेमासे रोहिण्याम् अष्टम्यां द्वादशमुहूर्तो दिवसो भवति, अष्टादशमुहूर्ता रात्रिः । ग्रीष्माणां पश्चिमे मासे रोहिण्याम् अष्टम्याम् अष्टादशमुहूर्तो दिवसो भवति, द्वादशमुहूर्ता रात्रिः । वर्षाणां पश्चिमे मासे रोहिण्याम् अष्टम्यां चतुर्दशमुहूर्तो दिवसो भवति, षोडशमुहूर्ता रात्रिः"

103. Eng. Trans. of the Jātakas, edited by Cowel I. 65, III-222, VI-228 etc.

104. Dīghanikāya, Eng. Trans. by Davids, Part I, I.I.24. p. 20.

about the eclipses. Then does it signify that the author of the work knew their astronomical theory, on the basis of which he has spoken of forecasting regarding the eclipses.

According to the Vaṇṇupatha Jātaka[105] travellers ascertained the quarters at night by the help of stars. Some translators of the Jātakas assert that the direction crows (दिशाकाक)[106] were also used for finding quarters.

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105. Trans. of the Jātakas, Cowel, Vol. I, Jātaka 2.
106. Text edited by Fauseboll, No. 384 (बवेरु जातक). Jātaka No. 339 (धम्मपद जातक). Vide Hindi Trans. of Jātakas by Ānanda Kauśalyāyan.

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Development of Geographic Knowledge in Ancient India [Āryavarta]

CHAPTER III

The Earth

Its solidification
Origin of continents and ocean beds
Earth's Interior
Geology
Earthquake
Volcano-vulcanacity
Theory of Isostasy
Other terrestrial phenomena.

CHAPTER III

THE EARTH

The Vedic Background

The Ṛgvedic interrogator inquisitively and very aptly asks the relevant question of Geography.[1]

"I ask thee, (Institutor of the rite), what is the uttermost end of the earth. I ask thee where is the navel of the world. I ask thee, what is the fecundating power of the rain-shedding steed.....!"

But the institutor of rites fails to give right answer to such a question and takes him into the jungle of ritualistic facts.

However, a few scattered lines of hymns provide various geographic informations which are being culled here. In the Ṛgveda X. 81. 1 the earth is visualised as a fiery ball in some distant past. I. 59. 2 states that Agni (fire) is the navel (core) of the earth. VII. 4. 5 also speaks of "the earth containing Agni (fire)." The lines II. 12. 2 tell us of "making the earth firm," "tranquillising mountains" and "consolidating the heaven." In X. 121. 4-5 we find a reference to the solidification of the earth having oceans. These three verses perhaps point to the idea that the earth initially was in a "molten state" or in such a state which might have been gaseous or liquid, but not solid.

Mantras I. 37. 7-8 definitely refer to the phenomena of earth-quake and Marut is said to be its cause. This is further confirmed by the continuation of the idea in the near about dates of the beginning of the Christian era when Uśanas opined[2]—

1. I. 164. 34.
2. Quoted in Vallālsena's Adbhutasāgara p. 385 vide the posterior pages of the same.

चत्वारीमानि भूतानि कम्पयन्ति वसुन्धराम् ।
आपः शचीपतिश्चैव हव्यवाहः प्रभञ्जनः ॥

The verse VIII. 20. 5 corroborates the same fact. It cannot be said with certitude whether the Ṛgveda knew of volcanoes, but there is an allusion to the association of Agni (fire) and mountains, so it has been said—"Agni, the upholder of mountains."[3] In the two verses[4] fire is said to be the devastator of cities. But it cannot be surmised with certainty that it points to volcanic erruption.

It is not known why mountains were called the maintainer of the balane of the earth (भूधर) and said to be moving from place to place in a very great antiquity in the Indian mythologies, but the two assertions are found in the Ṛgveda initially. If we try to interprete them scientifically (remembering that several natural Geographical and meteorological phenomena in the Ṛgveda are represented figuratively and symbolically) as "Bergaigne interprets the frogs as meteorological phenomena,"[5] we can see in the aforesaid statements a glimpse of the theory of Isostasy[6] and conception of continental drift, Zwischengebirge[7] and orogenetic processes.[8] Even without any mythological colouring, the plain words of the two statements signify the same thing.

Taittirīya Sanhitā says that formerly people knew only a small portion of the earth and there was no plant life on it. Later on they came to know its larger tract and plant life came to exist.[9] Like the Ṛgveda[10] the Śukla Yajurveda[11]

3. VII. 6. 2.
4. VII. 6. 1-2.
5. Vedic Mythology, p. 151.
6. VII. 99. 3.
7. II. 17. 5.
8. "Mountain building" Chapt. VI, The Physical Basis of Geography, Wooldridge and Morgan.
9. II. 1. 2-3.
10. VI. 7. 1.
11. VII. 24.

shows that those Aryans were acquainted with the fact that the interior of the earth is fiery. This fact is further established by the mantra "मातेव पुत्रं पुरीष्यग्निं स्वे योनावभारुखा"[12]

In the Atharvaveda there is a reference to crumpling and upheavels in the mountaneous areas.[13] Later on it alludes to earth-quake.[14] In a subsequent Kāṇda there occurs a line which points to the fact that the sages knew that the earth was solidified and became firm at a later period after its genesis.[15] In a certain context perhaps volcano is also mentioned.[16] The Sāmveda[17] reveals that the contemporary people were acquainted with earth-quake and tectonic movement in the earth crust.

The Epic Sources

Several verses of the Rāmāyaṇa may be interpreted to say to a certain extent that the earth was or remained a fiery ball at a certain stage of its life-history (literally universal dissolution).[18]

Although the verses I.37.16-17-18 are generally legendary, still they appear to refer to some sort of igneous, volcanic and gaseous activity in combination with mountain building or orogenetic processes. The Rāmāyaṇa had definite knowledge of volcanoes as is indicated in V. 35.43. Abrupt large depression of the earth crust, gushing out of it of subterranean water, rumbling sound of the interior of the earth, enveloping or burning of a place with the fire of Rāma's arrow or volcanic activity and origin of a characteristic land form desert are clearly expressed in the VI.22.34 and 40. At a place[19] there is a clear mention of "two craters aglow

12. Ibid XII. 61.
13. II. 5. 5.
14. XIX. 9. 8.
15. XIX. 32. 9.
16. XX. 34. 2.
17. II. 3. 7.
18. I. 55.28; I. 56. 19.
19. V. 1. 56 (Trans-M. N. Dutta, p. 877).

on a mountain", though Tikākāra wrongly or rather unsuitably interprets it to be forest fire.

Earthquake is repeatedly mentioned in the Rāmāyaṇa.[20] Very intensive earthquake shaking gigantic mountains is referred to at V. 35. 45. The phenomena of the earthquake and mountain crumbling taking place simultaneously are also most explicitly stated.[21] The cause of the earthquake is given to be "when on the sacred days the mighty elephant from fatigue, shaketh his head, then takes place the earthquake."[22] It is different from that stated in the Bhārgavīya[23] where Indra, Varuṇa, fire and Marut are said to be the cause of the earthquake. Thus it is evident that the Rāmāyaṇa was fully acquainted with the volcanic activity, earthquake and their effect on land formation and allied phenomena.

The Rāmāyaṇa touches upon the origin of ocean beds and thus indirectly upon that of continents.[24] But it is all mythical, there is nothing scientific in it. It points only to the inquisitiveness and speculation about a very important geographic phenomenon and is nothing more than that. The excavation described in I. 40 further indicates intellectual curiousity for geology in general.

The phenomena of tectonic movement and submergence;[25] of rising of a mountain in an ocean deep[26] of

20. I. 65. 14, IV. 39. 9; and VI. 77. 13.
21. I. 67. 18.
22. I. 40. 15.
23. Quoted in the Adbhutasāgara by Vallālasena. Here Indra, Varuna, Agni and Marut can be symbolically explained thus—Indra=tectonic movement and upheavel, Dynamic cause; Varuna=Water activity (percolation); Agni=Thermal cause and activity; and Marut=Gaseous activity.
24. I. 5. 2. and VII. 23. 21.
25. I. 45. 27.
26. III. 33. 6.

horizontal and vertical movement of mountain or earth-crust;[27] of submergence due to earthquake (literally wind) amidst the ocean or in the vicinity of ocean;[28] of submergence of a very high mountain and genesis of level pain[29] are also referred to. There is a sort of mythical reference to the geological core or centre of the interior of the earth in VI. 74. 56.

We also read about a dry bed of an ocean.[30] A verse[13] alludes to the legend of the sucking or drying of the ocean bed by Agastya and its replenishing by the Gaṅgā.

In canto 37 of the first Book we find a description of the genesis of minerals, igneous and water activity and allied geographic process. "Thereupon that partaker of oblations offered unto gods, said unto Gaṅgā, 'Do thou bring forth thy embryo on the side of the Himavat.' Hearing Agni's words, Gaṅgā of might energy cast her exceedingly effulgent embryo or her streams, on sinless. And as it came out of her it wore the splendour of the molten gold and in consequence of its fiery virtue, objects near and objects far were converted into gold and silver of unsurpassed sheen, while those that were most distant were turned into copper and iron. And her excreta were turned into lead. In this wise, various metals began to increase on earth. And as soon as the embryo was brought forth, the woods adjoining the mountain being overspread with that energy were turned into gold."[32] Of course it is mostly legendary and contains only a very small amount of scientific truth that minerals are generally found in igneous rocks and occur in a mixed state. Further, it points to the knowledge of contact metamorphism.

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27. V. 1. 92.
28. V. 1. 118-19.
29. V. 56. 49-50.
30. II. 47. 18.
31. I. 24. 4. (together with commentary).
32. I. 37. 16-21.

In the Mahābhārata there occurs a mention of a volcano emitting molten material.[33] This definitely indicates the volcanic erruption. Allusions to earthquake are also numerous. About the rising of land masses we read thus, "the earth.....rose up with her seven insular continents, mountains, rivers and forests to a height of four cubit.[34] The legend[35] of drinking of ocean by sage Agastya points that those people attempted to study or at least mark the drying of ocean bed. In a certain context it is said that mountains are protruding to a very large extent below the earth.[36] This statement fully agrees with the modern theory of Isostasy.

Perhaps artificial drying of ocean beds (just like that carried on in the construction of dykes in the Netherlands) is referred to in the Viṣṇu Parva of the Harivaṁśa.[37]

The Manusmṛti

In discussing the cosmogony of the Manusmṛti in chapter one of this treatise, we have seen how the author of the work possessed intellectual curiosity about the origin of continents and ocean beds and advanced also a theory of his own regarding the same.[38]

Chapter one of the Manusmṛti reveals that since the time of its creation, our earth has completed 1,969,103,000 years. Computations of modern geologists also assign approximately the same age to our planet.[39]

33. V. 181. 30. (Mahābhārata) (MND. p. 249).
34. Mbh. VIII. 90. 104.
35. Ibid. III. 105.
36. Ibid. I. 18. 3.
37. II. 58.38.
38. I. 23.24. But from fire, wind and the sun he (the creator-Brahmā).....drew forth...the oceans, the mountains, plains, and uneven ground.
39. Vide Manu-Dharma-Śāstra by K. Motwani p. 23.

The Puraṇas

The concept of floatation[40] and origin of mountains and and continents are given thus in the Mārkaṇḍeya Purāṇa :—

"The earth floated like an immense boat on the ocean, but did not sink by reason of the amplitude of its size. Ṭhen he made the earth level and created the mountains on the earth. Formerly when it was burnt up by the then world destroying fire, those mountains on the earth were totally consumed by that fire. The rocks were engulfed in that ocean, and the water was driven together by the wind; wherever they adhered and remained, there the mountains grew into being. Then he divided the earth; adorned with seven dvipas, and....."[41]

From the study of this paragraph, we come to three conclusions :—

(i) At some initial stage mountains were created by Brahmā.

(ii) Later they were formed out of growth of some rocky mass or structure, which implies implicitly the activity of orogenetic forces. Then the words "adhered" and "remained" point to assertion of concept of Zwischengebirge.[42]

(iii) Originally all landmass was a unified structure, and at some later period it was divided or rifted into several segments of continents. It would not be a farfetched or forcibly imported idea if we try to read here the concept of Pangaea and theory of continental drift propounded by the German Geologist Wegner in 1912.[43]

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40. Compare it with the latest theory of floatation of Sial in Sima (Theory of Isostasy Woordridge and Morgan. Almost the same line of Garuda is interpreted similarly by Dr. H. C. Raychaudhary-Studies in Indian Antiquities p. 64-65.
41. Mārkaṇḍeya 47. 10 to 14.
42. Compare Anterior p. 56.
43. Vide Chap. IV, "Physical Basis of Geography."

Similar verses occur in the Viṣṇu Purāṇa[44]—

तस्योपरि जलौघस्य महती नौरिवास्थिता
वितत्वात्तु देहस्य न मही याति संप्लवम् ॥४६॥
ततः क्षितिं समां कृत्वा पृथिव्यां सोऽचिनोद् गिरीन् ।
यथा विभागं भगवाननादि परमेश्वर ॥४७॥
प्राक् सर्गदग्धानखिलान् पर्वतान् पृथिवीतले ।
अमोघेन प्रभावेण ससर्जामोघ वाञ्छितः ॥४८॥
भूविभागं ततः कृत्वा सप्तद्वीपान् यथातथम् ।
भूराद्यांश्चतुरो लोकान् पूर्ववत् समकल्पयत् ॥४९॥

It can be easily seen that here the concept of Zwischengebirge and orogenetic forces which we tried to read logically and relevantly in the preceding lines of the Mārkaṇḍeya Purāṇa are altogether absent.

Dilating on the same subject almost in similar terms the Vāyu Purāṇa says[45] that the mountains were created with hard rocks.

Like the Manusmṛti, the Purāṇas also give information regarding the age of the earth in their chapters on Kālaswarūpa (measures and divisions of time) and Manvantaras,[46] the latter being one of the chief characteristics of that literature. The age of our planet computed according to these data corresponds fairly well with that given by modern science. It appears that the Purāṇas had some conception of lithosphere, Pyrosphere and Barysphere-like divisions of the earth. They had divided the whole depth of the earth into seven such spheres or strata which they called seven

44. Anśa I. IV. Compare; The Skanda, Māheśwar Khāṅda, Chapter 37. 14-15; Vāyu-8. 12 to 16 and other Purāṇas.
45. 8. 14 (.....शिलाभिरचिनोद् गिरीन्)
46. Viṣṇu Purāṇa Anśa 1, III. 8 to 28; Anśa 3, Chapter I and other Purāṇas.

pātālas (interior spheres or regions of the earth). The Viṣṇu Purāṇa has it[47]—

विस्तार एष कथितः पृथिव्या भवतो मया ।
सप्ततिस्तु सहस्राणि द्विजोच्छ्रायोऽपि कथ्यते ॥१॥
दश-सहस्रमेकैकं पातालं मुनि सत्तमा,
अतलं वितलं चैव नितलं च गभस्तिमत् ।
महारण्यं सुतलं चाग्र्यं पातालं चापि सप्तमम् ॥२॥

The Viṣṇuchittiyavyākhyā comments thus on these "विस्तार इति । सप्ततिसहस्रोच्छ्रायत्वं सप्तभूमिकप्रासाद-न्यायेन ॥१॥ दशसहस्रमिति ॥ दशसहस्रेण भूमितद्विवरमानविभागः ....." "The height of seventy thousand just like seven storeys of a building." This clearly shows that the Purāṇakaras had definitely stratum-conception in the mind resembling barysphere, prysosphere and the like of modern geology. This is further corroborated by an attempt at the description of the geological structure शुक्लाकृष्णारुणाः पीताः शर्कराः शैल काञ्चनाः ॥[48]

By the time of the Purāṇas, Indians had come to acquire sufficient knowledge of volcanoes, volcanic erruption, activities, allied phenomena and earthquake. But so far as the causation of volcanoes is concerned, they advanced merely mythical explanation, though that appears to contain a grain of scientific truth also, if we interprete the mythical facts symbolically, for which there is sufficient logical ground due to the terms used in the picturesque description of the phenomena.

The Brahma-purāṇa[49] describes a volcanic phenomenon in the following words—

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47. The Viṣṇu-Aṁśa 2, Chapter 5, Agni Purāṇa 120. 1
तलानां चैव सर्वेषामूर्ध्वतः सप्त सप्तमाः ।
क्ष्मातलानि धरा चापि समधा कथयामि वः ।
Liṅga Purāṇa—45. 23 Compare Siddhāntaśiromaṇi-Bhuvankośa—23.
48. Viṣṇu Aṁśa 2, V. 3.
49. Chapter VII.

अन्तर्भूमिगतस्तत्र वालुकान्तर्हितो महान् ।। ६२ ।।

.....

संवत्सरस्य पर्यन्ते सनिश्वासं विमुञ्चति ।
यदातदा मही तत्र चलति स्म नराधिपः ।।६४।।
तस्य निश्वासवातेन रज उद्धूयते महत् ।
आदित्य प्रथमावृत्य सप्ताहं भूमिकम्पनम् ।।६५।।
सविस्फुल्लिङ्गं साङ्गारं सधूममतिदारुणम् ।
तेन तात न शक्नोमि तस्मिन् स्थातुं स्वाश्रमे ।।६६।।
मुखजेनाग्निना क्रोधाल्लोकानुद्वर्तयान्निव ।।

Here the emission of dust, fire, sparkles and smoke points to the close observation of the entire volcanic phenomenon. The term निश्वासवातेन indicates a perception of erruption due to gaseous force or gushing out of steam. Mention of earthquake implies an accompanying phenomenon.

Similarly the Vāyu Purāṇa[50] also gives a vivid description of a volcanic tract—

मध्ये तस्यां शिलास्थल्यां त्रिंशद्योजनमण्डलम् ।
ज्वाला सहस्र-कलिलं वह्निस्थानं सुदारुणम् ।। ३९ ।।
अनिन्धनस्तत्र सदा ज्वालामुखी विभावसुः ।
ज्वलत्येष सदा देवः शश्वत्तत्र हुताशनम् ।। ४० ।।
अधिदेवकृते योऽसावग्रे भागो विधीयते ।
स तत्र ज्वलते नित्यं लोकसंवर्तकोऽनलः ।। ४१ ।।

The word त्रिंशद् योजनमण्डलम् implies a large volcanic area covering not less than 200 square miles.

Perhaps in the entire Indian literature, the term ज्वालामुखी occurs for the first time in the Śivapurāṇa :—[51]

पतिता पर्वते तत्रपूजिता सुखदायिनी ।। ४१ ।।
ज्वालमुखीति विख्याता सर्वकर्मफलप्रदा ।। ४२।।

one of the famous Pauranic mountain Vaibhrāja, was a volcanic one and was named so due to its igneous activity.[52]

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50. Chapter 38. Vide Śiva-Purāṇa Uttara V. 37. 16-17.
51. II. 2. 2. 41-42.
52. The Matsya 122. 18.

यस्माद् विभ्राजते वह्निर्विभ्राजस्तेन स स्मृतः ।

In connection with volcanoes, earthquake has already been referred to. The preceding paragraphs have also exhibited that the two may be concomitant phenomena. Earthquake, crumpling of mountains and other phenomena of tectonic diturbances are described thus in these lines— ".....and struck by the downfall of the mountains the earth quaked; and the earth as it quaked, caused the waters of the seas to swell up, and reeled over one side turning towards the descent to Pātāla."[53] About the cause of earthquake the Viṣṇu Purāṇa says, "when the infinite (or the mythical serpent) having restless eyes yawns with joy, the earth having oceans and woods quakes."[53a]

Projection of mountains below the surface of the earth is spoken of in several Purāṇas.[54] The Bhāgavata refers to the Meru's "root lying under the earth to the depth of the same extent."[55] The Vayu Purāṇa[56] explicitly states that the mountains maintain the balance of the earth. In these we can with all reasonability, search for some acquaintance with the theory of Isostasy. This is all the more understandable and accountable when we think in the vast vista of time also beginning from the Ṛgvedic era.[57]

In a line of the Skanda Purāṇa[58] we read about the recession of ocean waters :—

समुद्रेण प्रदत्ता मे भूमिर्द्वादशयोजना ।। २५ ।।

Seismology

As astronomy and mathematics were cultivated separately and assiduously in ancient India, similarly seismology

53. Mārkaṇḍeya-IX. 16-17.
53a. Aṁśa 2, Chap. 5, verse 23.
54. Mārkaṇḍeya 54. 15, Liṅga 48. 2 and others.
55. V. 16. 7.
56. 35. 11.
57. Anterior p. 56.
58. Prabhāsa, Dvā. Mā 4. II. 25.

received due attention in this country from the very early days, much anterior to Christian era. But the methodology of its study was exactly the same as in the case of astronomy—it was studied from two angles of vision—the occult or astrological and scientific. Generally the two phases have been intermixed and much of the treatment is of legendary and imaginary nature frequently smacking of primitive inquisitiveness. However we should make an analysis of the old Indian Seismology. Almost all the ancient writers on such branches of knowledge, namely Kāśyapa, Garga Vaśiṣṭha, Uśanas, Parāśara, Vṛhaspati and Varāhamihira have dwelt on this topic. The last named writer has devoted a full-fledged separate chapter (32) in his Vṛhatsanhitā to the seismology and named it भूकम्पलक्षणाध्याय. The Adbhutasāgara by Vallālasena (12th century) is a repository of information on this science. It treats of the subject exclusively in its भूमिकम्पाद्भुतावर्त (a chapter) covering nearly 25 pages. This is a collation of information extracted from different sources and works of very ancient times.

Regarding the cause of Earthquake Vṛhatsanhitā quotes the opinions of various schools[59]: "Some say that earthquake is caused by the forces (सत्व) obtaining in the interior of the earth; others assert that it is produced by the tired panting of quarter elephants who bear the burden of the earth; another group opines that it results due to rumbling wind (gaseous) disturbance in the interior of the globe; still other authorities aver that it is a consequence of undefinable causes."

Here the word सत्व is often explained to imply "beings." But there are two conspicuous points about the use of this

59. Adbhutasāgara p. 383.

क्षितिकम्पमाहुरेके मह्यन्तर्जलनिवासिसत्वकृतम् ।
भूभारखिन्नदिग्गजनिःश्वास समुद्भवं चान्ये ।
अनिलोऽनिलेननिहतः क्षितौ पतन् सस्वनं करोत्यन्ये ।
केचित् त्वदृष्टकारितमिदमन्ये प्राहुराचार्याः ।

term. Firstly, everywhere by all the authorities invariably only the word सत्व is used, and not any of its synonyms. Secondly one of the meanings of सत्व is energy or force also.[60]

Kāśyapa further says—

अर्णवस्योपरि पृथिवी सशैलवनकानना
स्थिता तन्मध्यगाः सत्वाः सक्षोभाच्चालयन्तिताम् ।

Garga gives the legend of panting of tired quarter elephants.[61] Vaśiṣṭha says, "When a strong wind collides with the atmosphere in the space, it at once comes down, and there is rumbling produced by the wind. When that coming down wind comes in contact with earth percolated by water, there takes place rumbling and earthquake is produced by that contact or collision".[62] Though Vaśiṣṭha happens to mention a part of the true cause of earthquake when he talks of "percolation of water," it is not understandable how he embarked upon the whole of the above idea, which is so fantastic, incoherent and hotchpotch.

Among all these authorities Uśanas appears to be most scientific and logical, though he also has not been able to free himself from mere guess work. He declares[63] :

चत्वारीमानि भूतानि कम्पयन्ति वसुन्धराम् ।
आपः शचीपतिश्चैव हव्यवाहः प्रभञ्जनः ।।
पूर्वां सहस्रनयनो दक्षिणां हव्यवाहनः ।
आपः पश्चाद् उदीची च स चचाल प्रभञ्जनः ।।

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60. "द्रव्यासु व्यवसायेषु सत्वमस्त्रीतु जन्तुषु"—अमरकोश
According to Monnier Williams also सत्व implies energy. Cf his Sanskrit—English Dictionary p. 1135.
61. Adbhutasāgara, p. 383.
62. Ibid p. 384.
यदातिवलवान् वायुरन्तरीक्षानिलाहतः ।
पतत्याशु सनिर्घातो भवते वायुसंभवः ।।
तस्ययोगान्निपतश्चलत्यद्भ्यो हतक्षितिः ।
सोऽभिघातसमुत्थः स्यात् सनिर्घातमहीचलः ।।
63. Adbhutasāgara, p. 385.

"There are four factors—Water, Indra, Fire and Wind, which cause earthquake." Then in the other verse are mentioned specific quarters in which various agencies bring about earthquake. Uśanas is quite scientific declaring the causation by water, fire and wind.[64] The Aindra factors most probably symbolically point to causation through tectonic or dynamic disturbances. This embraces the modern thermal cause of geologists. But the latter verse is totally absurd in the modern scientific eyes, unless we give it a farfetched symbolic meaning, that is the cause of earthquake in the east (Assam areas) is tectonic, in south (Deccan) is igneouses; in the west (ocean flanks and islands) water percolation, and in the north (Kashmir area) gaseous.

Mayūracitraka (by Varāhamihira), Parāśara, Garga Vṛhaspati, Bhārgavīya, Atharvaṇādbhuta and various other authorities[65] furnish some more information on earthquake, but it is all mythical, fanciful and full of meaningless occult speculation resembling that of astrology. In this speculation are given the times of day or night, when different traditional types of earthquake (caused by wind, fire, Indra and Varuṇa) occur. There are described the auspicious and inauspicious influences of the correlation of time and direction of each of the classes. Here it is unnecessary to discuss all the details provided, as they are altogether unscientific and baseless.

Bhārgavīya[66] speaks of harms and benefits accruing from earthquakes (शुभाशुभार्थं लोकानाम्). But it appears that it is most probably in the astrological strain, and those ancient writers here do not refer to the geological and geographical harms and benefits of earthquake, though they were or must have been acquainted with the latter fact.[67]

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64. Indra is said to be the breaker of mountains or highland areas (गोत्रभिद्) etc.
65. Adbhutsāgara, the pages following 385.
66. Ibid, the following pages.
67. But the Rāmāyaṇa had the knowledge of geological benefits of earthquake and volcanic activity, anterior p. 58.

The Bhārgavīya and Vṛhatsanhitā mention the seismological dimensions of influence of the aforesaid four types of earthquake. The Bhārgavīya says[68] that wind, fire, Indra Varuṇa produced earthquakes which cover a dimension of 120, 90, 80 and 70 Yojanas respectively. The Vṛhatsanhitā differs a little in this respect from the former authority and reveals that earthquake, caused by wind, fire, Indra and Varuṇa embrace a dimension of 200, 110, 180 and 160 Yojanas respectively.[69]

The Rājataraṅgiṇī gives very scientific description of the earthquake and its accompanying phenomena, perhaps its author Kalhaṇa had witnessed the flow of lava with his own eyes—

"भूकम्पैर्गण्डशिला नानाधातुद्रवैरिव"

".....just as big rocks (are deprived) by earthquakes of the various liquid minerals (contained in them).[70]

Science of gems and minerology was in quite developed stage in ancient India as is evinced by the Kautilya's Arthaśāstra (400 B. C.) some sections of the Puraṇas (e. g. Garuda chap. 68) various chapters of Vaidyaka (medical) treatise (Rasārṇava and Rasaratna samuccaya) and specific works on gems and minerology (रत्नविज्ञान or रत्नपरीक्षा). The study of these sciences, modes of occurence, exploitation and distribution of gems and minerals and other details furnished easily proved that practical geology or field geology[71] was in quite flourishing state in days of yore. Exclusive works on Dakārgala (science of occurence of underground water and water-table); devotion of a fullfledged chapter to it by Varāhamihira in his Vṛhatsanhitā[72] and reference to it by

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68. The Adbhutasāgara, p. 408.
69. Vṛhatsanhitā, Chap. 32. 28.
70. VIII. 1881.
71. Vide Chapter VII of the present dissertation.
72. Chapter 53 and Commentary by Bhaṭṭotpala.

Manu[73] also bear evidences to a tradition of study and application of Geology and allied sciences.

Architectural Sources

Bhoja's Samarāṅgaṇasūtradhāra[74] describes the origin of continents, ocean basins, mountains and rivers. It has considerably improved upon the traditional knowledge of the past on the topic and added something new to it and has attempted to present a better scientific theorisation in the field.

It says, "Initially the earth was a fiery ball युगान्ताग्नि प्लुष्टावस्था then it was in a cover of all water which is styled a single-ocean-stage (एकार्णवी अवस्था). Then with the help of very hot powerful rays of the sun, wind desiccated it and the earth began to come into existence and the infinite (name of a legendary serpent or symbolically the sky), Visnu's bed,

73. Cf. Posterior pages—Chapter IV.
The present author has come across a small interesting book named "Bhāratīya Viduṣī" (Hindi Trans.) by Manilala Gangopadhyaya, published by the Indian Press, Allahabad. It shows that science of Geology was assiduously cultivated in India near about the date of Varāhamihira and Mihira (the former's son). According to an anecdote narrated in the aforesaid booklet, not only Mihira, but also his wife Khanā had gone to foreign lands for the study of Geology. The wife even excelled the husband in this field. Thus it can be gathered that even women studied Geology. It is said in the anecdote that a large number of valuable treatises on the subject were thrown in the sea by Mihira due to his disgust for not being able to satisfy his preceptor about the excellent grasp of the subject. The anectdote may be true or false, but it definitely points to the fact that there was long tradition of the study of Geology.

74. Chapter IV. verses 20 to 27.

came to work as its support. Oceans were formed at places where water was not dried up. Dashed by Monstrous accumulation of waves, and tossed by violent wind portions of earth formed multifarious heaps at different places and resulted in the genesis of mountains. These stretched or bent the earth like hide-covers and began to function as the maintainer of equilibrium on its surface. Rivers sprang as the boundary-divider between mountains. In the intermediary space between oceans continents and islands came into existence. Thus earth with rivers, oceans, mountains, islands and continents was formed".

Here is evidently expressed the concept of "median masses". It is further fortified when we take into account the expression "जगाम घनतां पयः" occuring in the first line of verse 20. In it, therefore, is easily discribed the modern theory of orogenesis.[75] Then describing mountains as "the maintainer of equilibrium" on the surface of the earth points to some notion of theory of isostasy.

Jain Literature

The Jainas have tried to probe into the mystries of lithosphere, Pyrosphere and Barysphere. In the Tattvārthādhigama,[76] Tiloya Paṇṇatti[77] (5 century A. D.) and Jīvajīvābhigamopāṅgam[78] (before 250 B. C.) the same types of details are given; apart from the same scientific truths they contain large elements of imagination also. They divide the whole depth of the earth into seven regions 1—रत्नप्रभा, which has got three divisions खरभाग, पङ्कभाग, and अब्बहुलभाग.

75. Cf., "Mountain building" Chap. VI in the Physical Basis of Geography by Wooldridge and Morgan.
76. I-21; Suttra 1 and 2 and commentary on them; chapter 3.
77. Dwitīyamahadhikāra.
78. Sūtra, 69 and 73 and commentary. In this work the काण्ड word is used, and the commentator says काण्डं नाम विशिष्टो भूभागः the term Kāṇda implies a particular stratum of the earth.

खरभाग has got sixteen layers[79] 2—शर्कराप्रभा (pebbly or having the pebbly structure); 3—बालुकाप्रभा (sandy), 4—पङ्कप्रभा (muddy or viscous); 5—धूमप्रभा (gaseous) 6—तम: प्रभा (dark or unknown region) and 7—तमस्तमप्रभा (महातमस्प्रभा) (absolutely unknown or dark). All the three works give imaginary thicknesses also of the layers. In the commentary of Sutra 2 chap. 3, of the Tattvārtha it is said that in the abdomen of the earth temperature is so high that it can melt a heap of copper as big as the Himalayas.

Buddhists' Knowledge

In the Dīghanikāya there occurs a term लोकाख्यायिका[80]. T. W. R. Davids has translated it as ".....speculations about the creation of the land or sea." This points to the fact that the Buddhists had started speculations regarding the origin of continents and ocean basins.

In the Buddhist literature there occur numerous references to earthquake and volcanoes, their accompanying phenomena and effects. According to Sīlavanaga Jātaka[81] once solid earth burst as—under in a yawning chasm and flames came out from the nether region. Another Jātaka,[82] the Milindapañho[83], Mahāvaṁśa,[84] Divyāvadāna[85] and Dīghnikāya[86] also allude to earthquake. Milindapañho[87]

79. These are—1—रत्नकाण्ड, 2—वज्रकाण्ड, 3—वैदूर्यकाण्ड, 4—लोहित, 5—मसारगल्ल, 6—हंसगर्भ, 7—पुलक, 8—सौगन्धिक 9—ज्योतिरस, 10—अंजन, 11—अजनपुलक, 12—रजत, 13—जातरूप, 14—अङ्ककाण्ड, 15—स्फटिक, 16—रिष्ट रलकाण्ड.
80. I. 1. 17. p. 14.
81. Eng. Trans. of the Jātakas, edited by Cowel, Vol. I No. 72, p. 176.
82. Ibid, Vol. VI, No. 547, p. 253, 265.
83. IV. 1. 35, p. 170.
84. Eng. Trans. Geiger and Bode, 1920, III. 39-40.
85. p. 365.
86. Text edited by (Davids and Carpenter 16. 3. 13p. 107).
87. IV. 1. 35 p. 170.

says that there are eight causes of earthquakes. But all the causes enumerated there are legendary except one. According to this earthquake is caused when there is some disturbances in water (that is when it percolates the earth). Its predecessor Divyāvadāna[88] says the same thing. In this work and Milindapañho we read about tectonic movement and crumplings. The latter has सिनेरुगिरिकूट सैलसिखरो विनमानो होति.[89] The former presents a little more vivid account—"षड्विकार: पृथ्वीकम्पो जात: । इयं महा पृथ्वी चलति, संचलति, व्यधति, प्रव्यध्यति, संप्रव्यधति । पूर्वदिग् विभाग उन्नमति पश्चिमोऽवनमति, पश्चिम उन्नमति, पूर्वोऽवनमति, दक्षिण उन्नमत्युत्तरोऽवनमति.[90] In a subsequent Avadāna also the same thing has been repeated.[91] From the Mahāvastu[92] also we learn about subsidence and upwarping of land. In the eighth Avadāna of the Divyāvadāna there is a mention of volcano. From a particular reference in the Dīghanikāya it appears that the contemporary people knew forecasting also regarding earthquake.[93] But we know nothing or cannot ascertain the degree of scientific basis of this forecasting. According to Cowel and Neil the last portion of the Divyāvadāna which could not be edited due to the currupt state of the manuscript contained some facts of seismology.[94]

88. P. 204.
89. Edited by Vadekar, 1940, p. 121.
90. Divyāvadāna, p. 47.
91. Ibid. p. 365.
92. Mahāvastu, Eng. Trans. J. Jones-1949, Vol. I, p. 34.
93. Part, I, I. 1. 24. p. 20.
94. Edited by Cowel and Neil, p. 649-50.

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Development of Geographic Knowledge in Ancient India

CHAPTER IV

The Lithosphere

Topography
Physiography
Geomorphology (mountains, rivers, desert and the like).
Decipherment of relief profiles
Rocks
Soils
Erosion and other allied topics

CHAPTER IV

THE LITHOSPHERE

The Earliest Age

The "Vedic Mythology" by A. A. Macdonell outlines the physiography poetically described in the Ṛgveda in the following lines—

"According to the Ṛgveda she (the earth) abounds in heights, bears the burden of the mountains, and supports the trees of the forest in the ground (क्ष्मा). She quickens, for she scatters rain, and the showers of heaven are shed from the lightning of her clouds. She is great (मही), firm (दृढ़) and shining (अर्जुनी)."[1]

Besides a large number of rivers, lakes and waterfalls,[2] deserts,[3] snow-clad mountains,[4] mountainous fringes or table lands[5] and shelving banks of the Gangā[6] are other topographic features mentioned in the Ṛgveda. Vigorous erosion by the river Sarasvatī is alluded to in VI. 61. 2. The whole hymn VI. 61 gives the description of river banks. Further the "River Hymns"[7] of the Ṛgveda furnish poetic-cum-geographic account of a number of rivers.

Perhaps the Ṛgvedic Āryans had the concept of knowing slopes also of a region by the help of rivers as is indicated in IX. 88. 6.

By the time of the Sāmaveda, Yajurveda and Atharva-veda, the Indians had come to acquire sufficient knowledge

1. p. 88.
2. VIII. 7. 10.
3. V. 83. 10; VI. 62. 2. etc.
4. X. 121. 4-5.
5. Wilson's version. VIII. 85. 2.
6. VI. 45. 31.
7. X. 75.

of physiography and geomorphology. This is established by the following geographical technical terms—उपह्वर (mountain slopes),[8] इरिण (cleft or ऊषर), शिला (stony place), क्षयण (habitable place), काट (forest having a difficult communication), ह्रद (lake), लोप (rugged lands or bad lands),[9] नीप (skirt of mountains), सूर्व (good soil), किंशिल (pebbly grounds),[10] and अनूप (marshes)[11] Like the Ṛgveda, Śuklayajurveda[12] and Atharvaveda[13] also call a desert as धन्व or धनु. In the Taittirīyasanhitā[14] slope or a sloping place has been named as प्रवण. In the Sāmaveda we come across a brief but fine description of a river mouth—".....and as a wave of the sea opposite to the mouth of a river sends into it a portion of its water."[15] The Pṛthvī sūkta (XII) of the Atharvaveda furnishes a concise account of physiography—mountains, snow-capped mountain summits, forest lands, rocky places, high lands (उद्वत), plain areas (सम) and perennial streams or slopes (प्रवत). This Sūkta refers to various types of rocks and different soils of brown, black, red and other colours.

In the Gopathabrāhmaṇa, the nomenclature for a meandering river is विपाट्.[16] It was also acquainted with two types of springs or falls, namely hot and cold.[17]

The Rāmāyaṇa

The celebrated epic reveals very rich and accurate knowledge of various types of geomorphological patterns—

8. Sāmaveda Prapāthaka, II. 5. 9. Text.
9. Taittirīyasanhitā, IV. 5. 9. 1 (Keith).
10. White Yajurveda, XVI. 37-45.
11. Atharvaveda, I. 6. 4.
12. XXXIV. 24; p. 282 (Griffith).
13. I. 6. 4.
14. VI. 2. 6. 4.
15. XIV. 4. p. 163 Stevenson.
16. II. 8.
17. "..... शीतोष्णाविहोत्सौ....." II. 8 (उत्स = a spring or falls).

mountains and plateau topography, plains, swamps and deserts.[18]

Some of the geomorphological patterns in the Rāmāyaṇa are quoted below—

"And romantic forests and woods, watery expanses of mighty volume, and mountain with flat places."[19]

"Rivers and rills and plateaus, caverns, and fountains."[20] "That plain tract."[21] "Sandy banks of rivers."[22]

"Those lands watered by the Gaṅgā are dense and hard to track."[23]

"That spot widening into a level plain measuring five yojanas was covered with thick grass.....on it stood..... citrous and myrobalan."[24]

निर्दर—disintegrated or cracked rocks[25] शैलप्रस्थ—plateau,[26] उद्भेद—fountains; निष्यन्द—rillets, जलप्रपात—cascade or falls,[27] descent of a river,[28] bridge of sand, mountain hollows, caves, cavities and rills,[30] and swamps or marsh.[31]

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18. VI. 22, 33 and 37.
19. II. 48. 10 (MND p. 323).
20. II. 54. 42.
21. II. 56. 11.
22. II. 55. 31.
23. II. 85. 4 (MND, p. 419).
24. II. 91. 29-30.
25. II. 92. 10.
26. II. 94. 11.
27. II. 94. 13.
28. II. 103. 25.
29. III. 69. 50.
30. IV. 13. 6—

    कन्दराणि च शैलाश्च निर्दराणिगुहास्तथा ।
    शिखराणि च मुरव्यानि दरीश्च प्रियदर्शना ॥

31. III. 33. 5.

How after melting of snow, a mountainous topography becomes charming is spoken of thus—हिमात्यये नगमिव चारु-कन्दरम्.[32]

Occurrence of mountains in oceans is mentioned in III. 33. 6 and VI. 50. 32. Further references to ocean deeps and submarine mountains are also found in IV. 41. 20 and IV. 42. 30. The Rāmāyaṇa has made very subtle observation of oceanic lake (like Cilkā of Orissa).[33]

The author of the epic has also marked "river erosion on non-resistent or soft steep river bank.[34]

In VII. 23. 42 we read about the erosive action of the downpour of rain on mountains.

Thus through a close study of the cantoes, it can be easily seen that the following words of the celebrated geologist Edward Suess about the perfection of the physiographical knowledge of the ancient Hindus apply to none so aptly as to the outstanding literary masterpiece. "The Hindus have devoted a terminology much more perfect than our own to denote the superficial features of the ground and it is a question whether many of their designations might not with advantage be more generally employed."[35]

The poet of the Rāmāyaṇa has once referred to ūṣara (barren) soil also.[36] II. 100. 68 again mentions uṣara or barren soil in the Pañcavargas.

The magnum opus speaks of various types of rocks of different colours—green,[37] coral,[38] blue, red, white, and black ones together with others of different colours.[39]

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32. V. 7. 15.
33. II. 14. 66. (The Kāmyakasara of old).
34. II. 63. 46; V. 34. 19; VII. 14. 18.
35. "The face of the earth", vol 1. p. 48.
36. VII. 86. 14. (Ṭikā by Tilaka and MND canto 99).
37. III. 35. 18.
38. III. 35. 24.
39. V. 1. 5.

Two chapters (Bhūmi Parva—11 and 12) of the Bhīṣma Parva of the Mahābhārata contain considerable information on physiography. The Mahābhārata mentions large tracts of deserts several times.[40] In a certain context the word नदीकच्छ is used. Most probably it indicates the land form for which now-a-days the appellation Delta is used.

The Mahābhārata divides the Himalayan mountain into three regions—the outer Himalayas, the lesser Himalayas and the interior Himalayas.[41] It appears that those people had geomorphologically or physiographically studied or at least carefully observed the great mountain and on that basis distinguished its three parts.

The great epic describes the soil of a forest area in these words: "Its soil was uneven and covered with blocks of stones, loosened from the hills."[42] It unmistakably evinces that the author had carefully observed and was acquainted with the geomorphological process of solifluction or soil creep.

Manu as the Specialist of Dakārgala

Very little is known about the actual life of Manu, the great writer. Again it is not known with certitude how many such Manus flourished in ancient India. We are generally acquainted with Manu who wrote Manusmṛti or Mānava-dharmaśāstra But there appears to have been another Manu who was a great scientist. Two scientific works are ascribed to Manu—Mānavaśulvasūtra and Dakārgala (the science of underground water and water-table). The treatise on Dakārgala (or Dagārgala) by Manu is referred to in the Vṛhatsanhitā.[43] It is irrelevant in the present context to attempt at any detailed discussion whether the authors of Mānavaśulvasūtra and the Dakārgala were the same scientist. But there seems every likelihood that the writer of the Dakārgala, referred to by Varāhamihira, flourished near about

40. I. 70. 2.
41. II. 27. 3.
42. I. 69. 17.

400 B. C. or 200 B. C. by the latest. And as Varāhamihira and his commentator Bhaṭṭotpala (966 A. D.) allude to him in the expression "वृत्तैरपि मानवं नक्ष्ये"[44] and "मनुना विरचितं दकार्गलम्"[45] respectively, it points to the fact that the celebrated scientist must have written a full-fledged dissertation on दकार्गल or science of underground water and water-table.

Varāhamihira has relevantly drawn upon Manu's Dakārgala. Even the expressions of his verses 100, 101, and 102 of the chapter 53 are borrowed from the lines of Manu, as is revealed by the latter's five verses quoted by Bhaṭṭotpala in the commentary of the aforesaid three stanzas of Vṛhatsanhitā. Thus it is established that the particular branch of geology under consideration was scrupulously studied and cultivated in India several centuries before Christ and that it was developed by the indigenous people altogether independently or without the least foreign influence.

Varāhamihira has utilised to a greater extent another treatise on the science of underground water and water-table, written by Sārasvata. Rather the former appears to give a preference to the latter over the Mānavadakārgala. So far absolutely nothing is known about Sārasvata and his work, though Varāhamihira has mentioned him and Bhaṭṭotpala has quoted from his treatise profusely. From this at least one thing is certain that Sārasvata's work existed in the time of Bhaṭṭotpala, which the latter used frequently. Sudhākara Dwivedi, the renowned editor of the Vṛhatsanhita (vols. I and II) puts a question in the beginning of vol. II as to who Sārasvata was. But his querry remains unanswered. Researches on Sārasvata should be taken up in right earnest and *de novo* searches made for his work in various manuscript libraries inside and outside India. Similarly search for the full text of Mānava Dakārgala is another desideratum in the field.

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43. Vol II, p. 734.
44. Vṛhatsanhitā, 53. 99 (volume II).
45. Commentary of the above verse, p. 732.

Now so far as the subject proper, the science of underground water and water-table is concerned, a brief survey of chapter 53 of the Vṛhatsanhitā designated as "Dakārgalam" is furnished below and we shall rest content with it, as it embraces both the precursors Sārasvata and Manu and in the literature of the posterior age, so far discovered and discussed, little is available on this topic.

Apart from the wider term "Dakārgala," there are two other technical terms शिरा and शिराविज्ञान (occurring in Bhaṭṭotpala's commentary of verse 62) used in this Chapter (53). The former implies arteries of water or streams and the latter exactly conveys the meaning of water-table.

Verses 3,4, and 5 inform us that the sub-terranean streams are ramified in all the quarters. Verse I tells us that at some places water-table is higher and at others it is lower. From verse 2 we learn that water-table is a complex function of rain water. Water which falls from the sky originally has the same colour and the same taste, but assumes different colour and taste after coming down on the surface of the earth and after percolation. Then in the latter verses are given the modes of occurrence of sub-terranean water and its depth at different places. In these verses sometimes scientific facts are mixed with imaginary concomitances. But the rock or soil structure and depth of water-table from the surface of the earth is generally described correctly. Pervious and impervious strata are also referred to.[46]

From the point of view of occurrence of subterranean water, Varāhamihira has discussed three types of regions—जांगल[47] (area where water is not in abundance), अनूप[48] (where there is abundance of water at a comparatively small depth from the surface of the earth) and Marudeśa[49] (मरुदेश or desert tract).

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46. Verse 7, and with a little difference in meaning, verse III
47. Verses preceding 47.
48. Verses following 47.
49. Verse 62, and the following ones.

The occurrence of underground water in the desert region is quite accurately described by versatile Varāhamihira. He says that sub-terranean streams or water-table in the desert region takes the shape of the neck of a camel and is at a great depth from the surface.[50] Geological strata scheme of the modern artesian well fully corroborates this. (Cf the diagram given below). Later in verse 102 is described how water occurs in a mountanous region.

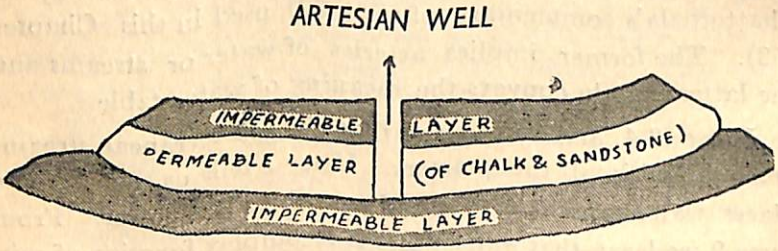

Fig. 1

Artesian wells are now-a-days a common phenomenon in all advanced desert tracts, for example Australia, Algeria and other regions (India inclusive).

In the verse 104 we read that pebbly and sandy soil of copper colour makes water astringent; brown-coloured soil gives rise to alkaline water; yellowish soil makes water briny; and in blue soil underground water becomes pure and fresh.

Grammarians :

In Pāṇini's Aṣṭādhyāyī (600-700 B. C.), we come across several important geomorphological patterns. The grammarian calls a river moving and breaking its banks as भिन्द्य and one whose waters overflow the banks as उद्द्य.[51] Glacier is named as हिमानी.[52] Melting of snow is referred to as

50. 53.62.
51. Aṣṭadhyāyī—Text and Eng. Trans. by S. C. Bose, III. 1. 15, p. 392.
52. IV. 1. 49. p. 633.

हिमश्रय.[53] To a desert he gives the Vedic name धन्व.[54] A low land or a land at the foot of the mountain and table-land or a high-land are referred to as उपत्यका and अधित्यका respectively, Pātañjali (200 B. C.), however understood by उपत्यका a low land in the sense of a valley.[55]

Arthaśāstra and Nītiśāstra :

Topography and Geomorphology have not been left out of the campus of the versatile genius of Kauṭilya (4th century B C.). At a certain place in his Arthaśāstra he refers to elaborate land utilisation survey, which must have necessitated extensive knowledge of varied topography.[56] In another context he talks of "such varieties of land as forests, villages, waterfalls, level plains and uneven ground", (and most probably implicitly of others also) "stretching between the Himalayas and ocean."[57] All this evinces that he must have been a student of not only topography, but also to some extent of geomorphology. At various places he speaks of fertile, infertile, cultivable, uncultivable and waste land, which reveals that he must have possessed good knowledge of the science of soil also.[58]

In the Śukranīti (200 B. C.) also "barren and rocky soils"[59] and "uneven grounds"[60] are mentioned which indicate knowledge of different types of soils.

Verses 9 to 15 of the Kāmandakīya-nītisāra (C. 320 B. C) indicate that elaborate topographic studies must have been in vogue for military purposes,[61] apart from the revenue requirements. Rendering of verse II would sufficiently

53. VII. 4. 29. p. 1264.
54. IV. 2. 121. p. 743.
55. *India in the time of Pātañjali*, by B. N. Puri. p. 70.
56. Part I, Adhikaraṇa 2, chap 35. 3.
57. Shamasastri, p. 412.
58. Ibid., p. 362-4
59. IV. 2. 230 (Eng. Trans. by B. K. Sarkar).
60. IV. 7. 268.
61. XIX. p. 250 (M. N. Dutta).

warrant this statement, "Devoid of sandy soils, mud, earthen mounds, gravels and stones and free from marshes, creepers. pit, trees,...and such like things."

Various Purāṇas :

The Vāyu Purāṇa refers to various types of topography, namely, lakes, dales, barren tracks,[62] rocky troughs between mountains (अन्तर्द्रोणी)[63] and longitudinal troughs lying between two filament like mountains,[64] rocky expanses[65] and dark mountain bowels.[66] The chapter also speaks of a large number of hot springs in a mountainous region—"तथा ह्यनल्प तप्तानि सरांसि द्विज सत्तमाः। शैत्यकुक्ष्यन्तरस्थानि सहस्त्राणि शतानि च ॥[67]

In the Mārkaṇḍeya Purāṇa we come across a peculiar type of topography found "in the Kimpuruṣavarṣa and seven other countries" where water bubbles up from the ground.[68] The Viṣṇu Purāṇa informs us of obliteration of relief due to dissolutional erosion in these picturesque words.[69] "The three worlds, consumed by these suns, become rugged and deformed all over their mountains, rivers and seas and the earth bare of verdure, and destitute of moisture alone remain resembling in appearance the back of tortoise." Submergence of landmass due to the invasion or activity of ocean is also alluded to.[70]

The Paurāṇic geographers must have been acquainted with the great obliteration of relief through tectonic processes, upheavals and vigorous erosion, as the Matsya Purāṇa says: "Further to it (Jaladhara) is the inaccessible Nārada mountain where were in ancient times the two mountains of

62. Chapter 38.
63. 38. 36.
64. 38. 45.
65. 38. 68.
66. 38. 77.
67. 38. 78.
68. 56. 21-22.
69. VI. 3.21-23.
70. Ibid., Eng. Trans., p. 438.

Nārada and Parvata."[71] The Garuḍa Purāṇa has recognised the exceptional erosive power of water which is said to be 'death or senility to mountain" (पर्वतानां जलं जरा).[72] In a certain context the Padma perhaps speaks of sand dunes[73]. (बालुकागिरि).

With slight variation several Purāṇas[74] classify the soils of subterranean regions (seven Pātālas) in seven categories (1) black; (2) white or yellowish; (3) blue or red; (4) yellow; (5) gravelly; (6) Hilly or boulder, and (7) golden hued.

A large number of the Purāṇas[75] assert that on the Meru-mountain four types of soils or rocks are found, namely, white in the east, yellow in the south, black on the west and red on the north.

The Padma-Purāṇa recognises[76] five types of rocks—quartz (metamorphic rocks); blue rocks (most probably granite and the akin ones). Indra blue rocks (perhaps a special variety of granite), yellow rocks, and white rocks (marble or steatite ?). In the Varāha-Purāṇa some particular type of rock has been given the appellation of भौमशिला (red rock or red sand stone).

The Vṛhatsanhitā also mentions a large variety of rocks permeable and impermeable rocks (पुटभेदक and अपुटभेदक),[77] black-rocks[78] (अश्माञ्जनोपम), white rocks,[79] whitish rocks,[80]

71. 122. II.
72. 115. 10.
73. 42. 181.
74. Brahmāṇḍa (Purva), XX. 13-14; Brahma, XXI. 3; Skanda (Maheśvara-khaṇḍa (Kaum. khaṇḍa), 39. 2; Viṣṇu II. 5. 3.
75. Varāha, 75. 15-17; Vāyu, 34. 47-48; Mārkaṇḍeya, 54. 14.
76. Uttarakhaṇḍa 221. 7 to 10.
77. 53. 7.
78. 53. 11.
79. 53. 10.
80. 53. 20.

white and black,[81] yellowish,[82] brownish,[83] frog-coloured,[84] Kuluthhued,[85] green[86] and copper rocks[87] (cuprite-chalcopyrite).

In this work four types of soils are recognised—white, red, yellow and black and their smells are given to be those of clarified butter (घृत), blood, grains and wine respectively.[88] The four classes are said to have four different tastes —sweet, astringent, acid and bitter or pungent respectively.[89]

Works on Architecture

The Mānasāra is perhaps the earliest (circa 25 B. C.) and the most important architectural treatise extant and known so far which furnishes considerable information on soils, their colour, taste, texture and smell and slope of a region.

In chapter III, it recognises four types of soils. The first type is said to have white colour, and sweet and fragrant taste; the second is reddish in colour and bitter in taste; the third yellowish in colour and sour in taste, and the last one has black colour and pungent taste.[90] In the following chapter it states of clayey scratchy and crusty soil, without husks, ashes and gravels.[91] Then later on we read about various odours of soils—those having the smell of honey, oil, clarified butter, burnt things, bird, fish and dead body.[92]

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81. 53. 44.
82. 53. 26.
83. 53. 30.
84. 53. 32.
85. 53. 36.
86. 53. 46.
87. 53. 71.
88. 52. 94.
89. 52. 95.
90. III. 18 to 29 (lines).
91. IV. 18-19 (lines).
92. IV. 21-22 (lines).

The same subject is dilated upon in the second and third chapter of the Mayamatam (a little earlier or later than Mānasāra). It speaks of six types of smell of soils—those having the odour of Pumnāga, nutmeg or jasminum, grandiflorum, lotus, paddy, rose or a particular flower (पाटल) and animals.[93] In the third verse it talks of homogeneous, solid, adhesive and smooth soil. In the following two verses it gives six varieties of soils having six different tastes—sweet, salty, sour, pungent, astringent and chillibitter. In the same verses it recognises a pigeon coloured soil also.

The Samarāṅgaṇasūtradhāra typifies three varieties of terrain—जाङ्गल, अनूप and ordinary.[94] Jāṅgala is a desert or an arid tract with black soil. Riverine fertile tract having a higher and easily accessible water-table is styled as Anūpa. The ordinary terrain combines the characteristics of the former two. The same authority repeats the information on the subject given by its predecessors.[95]

The Hayaśīrṣapañcarātra (between 400 and 800 A. D.) exhibits similar knowledge in its chapter VI. The Mānasollāsa or Abhilaṣītārthacintāmaṇi treats of examination of soil and tract of battlefield.[96]

All the above authorities in their aforesaid chapters recognise various types of slope (प्लव). The Aparājitapṛcchā (12th or 13th century A. D.) gives eight kinds of slope.[97]

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93. Mayamatam III. 2-3.
94. VIII. 2 to 6.
95. VIII. 48-49, 59, 65.
96. Vinśati 2, ch. 20. 1I68-69.
97. Edited by P. A. Mankad, Intro. P. XCIV. Eight kinds of slopes are—गोवीथि, जलवीथि, यमवीथि, गजवीथि, भूतिवीथि, नागवीथि, वैश्वानरी वीथि and घनवीथि.

This clearly evinces that the ancient Indians knew a lot about slope and its determination.[98]

In the Suśrutasanhitā (200 B. C.) also we have a discussion on soil or ground examination. According to this medical treatise there are two types of soil examination—(i) general and (ii) special. From the general examtinaion of a soil, we learn whether it is full of holes, boulders, pebbles, anthills, uneven...sandy, fertile or alkaline, bereft of joints or crevices, having higher or lower water-table, smooth and adhesive, soft and resistent to running water, and black, white and red in colour.[99] Special type of soil examination gives its five characteristics. Soil or earth which is pebbly, resistent, heavy, black, blue and abounding in vast vegetation cover is said to possess earth-characteristics (पृथ्वीगुणभूयिष्ठ). That which is smooth, adhesive and has a higher water-table, profuse humus and sufficient vegetation cover is known to be endowed with water-characteristics (जलगुणभूयिष्ठ). Soil having various colours strewn with small gravel and scattered vegetation cover is said to be possessed of fire characteristics. Dry, rough and ash-coloured soil with trees having small amount of moisture in their veins is acknowledged to be of wind-characteristics. Soft or even or homogeneous (समान) soil of unindentified qualities and water-table, full of useless trees, specially large mountainous ones and dark in colour

98. There is another class of literature known as Āgamas falling in the pale of Tantric treatises which also contains some geographical material on soil, orientation and the like, but that makes no new or special addition. Hence it has been generally omitted. The Āgamas are 28 in number and most probably were composed between pre-Christian era and 7th or 8th c. A. D., the most important being कामिकागम, कर्णागम, सुप्रभेदागम and वैरवानसागम. Here the date is based on "A History of Indian Literature" by Winternitz, vol I, p. 588.

99. Sūtrasthāna, chapter VI, para 3.

is said to be of sky characteristics.[100] The same tome asserts that according to several authorities there are soils of various colours—red, brown, yellowish, blue, deep yellow and white.[101]

Jaina Works

The Vṛhatkṣetrasamāsa is a reputed Jaina geographical treatise of the 6th or 7th century. Apart from dealing with the traditional geography, it has tried to probe into novel branches of the scinece. In the first Adhikāra[102] are given some speculations about geographic features, source, mouth and course of rivers. These enunciations are couched in such phraseology as appear to be quite scientific and mathematical conforming to some hydrographical or hydrological law, but actually they contain a very small grain of truth. One example would suffice. "The dimension of a river at its mouth when it enters ocean is ten times that it possesses at its source in a lake or the like,,'[103] The commentator, Malayagiri (between 1150 to 1250 A. D.), illustrates this theorem with an example. He says, "The Caṅgā and Sindhu at their source possess a dimension of 6 yojanas and a krośa (2 miles); this gives their expanse at the mouth to be 62 yojanas and 2 krośas according to the above enunciated law."[104]

Prajñapanā of Ayya Sama (Ārya Syāma, 250 B. C) classifies[105] terrains and ores into forty categories:—1. gravelly (rough and abounding in small pieces of stones); 2. sandy; 3. upal (several varieties of rocks and ores); 4. rocks; 5. salt or salt-rock; 6. Alkaline or barren soil; 7 to 13. ores of iron and the like; 14. diamond; 15-16-17. other rock structures; 18. Antimony 19. coral or coral reefs;

100. Ibid., para 4.
101. Ibid., para 5.
102. Verses 226-232.
103. I. 227.
104. The commentary on the above verse.
105. Chapter I, sūtra 15, with commentary of Malayagiri.

20. mica; 21-22. sand of mica (schist); 23. Gomedak (a variety of precious stone); 24. Rucaka (a precious stone); 25. Aṅka (अंक) (some stone); 26. crystalline rocks; 27. some red stratum; and 29 to 40. gems, granite and metamorphic rocks and sedimentary ores (like mineral sandal).

In the same work the preceding aphorism typifies seven classes of soil: 1. black; 2. blue (perhaps produced by granite and kindred rocks); 3. red (laterite); 4. yellow; 5. white; 6. brown clayey and 7. Panakamṛttikā (alluvial, debris deposition and clayey loam). It is really creditable to recognise such scientific classification of soils.

The Jīvajīvābhigamopāṅgam also furnishes some information on the science of soil. It recognises six types of soils[106] 1. fine grained clay; 2. pure soil found in mountainous regions; 3. Manahśilā (some rocky soil); 4. sandy; 5. pebbly and coarse; and 6. that abounding in stones and boulders.

The Malayagiri commentary on the above aphosism surmises about the approximate age of each of above soils. He says, "The first soil continues for a thousand years; the second for twelve thousand years; the third for fourteen thousand years; the fourth for sixteen thousand years; the fifth for eighteen thousand years; and the last one, for twenty-two thousand years." Most probably these statements embody some truth.

Buddhist Literature

The Aṅguttaranikāya classifies[107] lakes into four categories on a queer *fundamentum divisionis*—1. shallow appear-

106. Pratipatti 3, uddeśa 2, sūtra 101.

107. Aṅguttara Nikāya (P. T. S. London-1895-1900), Part II, p. 105. Ancient Indians made still more close study of lakes. In the Manusmṛti a lake has been termed as "गर्त" (IV. 203). Its commentator Kullukabhaṭṭa (between 1150 to 1300) cites a very scientific verse from the Chāndogapariśiṣṭa providing the definition of such a lake "धनुः सहस्राण्यष्ठौ च गतिर्यासां न विद्यते। न ता नदी शब्द-वहा गर्तास्ता परि-कीर्तिताः ॥". "Water-bodies which are 4000 cubit (हाथ) in dimension and which have no movement are not called rivers, but lakes (गर्ताः)".

ing deep; 2. deep appearing shallow; 3. shallow appearing shallow and 4. deep appearing deep.

In the Dīghanikāya a shelving beach has been termed as पहम्[108]. The Sumasumārajātaka has used the word निवर्तन for what is now-a-days known as river-meander.[109] In the Saṃyutta Nikāya there is another allusion to the determination of slope.[110] The Dhammapada Aṭṭhakathā[111] mentions several types of soil "even, uneven, abounding in mud, abounding in gravel, black, red, clay and red clay."

In a Jātaka[112] subterranean water and its science are also referred to. As has already been discussed, this science has great antiquity in India.[113]

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108. Part I, p. 283, footnote 2.
109. No. 208, p. 158, edited by Fauseboll. Eng. Trans. by Cowell.
110. Eng. Trans. by Mrs. Davids and Woodward, Vol V, p. 195.
111. Eng. Trans. Burlingame, 1921, Part II, p. 29.
112. Vaṇṇupatha Jātaka (No. 2), Eng. Trans. Cowell, p. 11.
113. Cf. anterior page (Dakārgalam).

Development of Geographic Knowledge in Ancient India

CHAPTER V

The Atmosphere

Climatology
Meteorology
Atmospheric Regions
Insolation and Evaporation
Albedo
Rainfall-classification
General Precipitation
Classification of clouds
Birth of Raingauge and Barometer.

CHAPTER V
THE ATMOSPHERE

The Earliest Dawn

The Ṛgvedic Aryans had keenly and carefully demarcated the various seasons and divided the whole year into six such divisions.[1] Three such bigger divisions—hot, wet and cold—are also recognised in Rv I. 164. 46. The sun was clearly known as the determinant of seasons.[2]

Radiation, convection-current and rainfall as their effect are described in the Ṛgveda,[3] and these verses also say that the rays of the sun are the cause of rains, and that the clouds are constituted of various elements. Insolation, evaporation, moisture, clouds and rainfall are referred to in I. 141. 2 as explained by Sāyaṇa. Instrumentality of winds in the causation of rainfall[4] and their relationship with clouds can be easily read in I. 19. 7-8. The mantra I. 38. 7 reveals how the moistureladen winds bring some scanty rainfall in desert regions also.

In two mantras[5] there are references to sixty-three and forty-nine types of winds respectively; their climatological and meteorological implications are still unravelled and they are mostly treated as merely mythologies. No clear-cut mention of the monsoon is to be found in the Ṛgveda, but the Marut hymns give its quite good and satisfactory descriptions; of course, monsoon is clearly referred to in the later period in the Yajurvedasanhitā as सलिलवात.[6] It will,

1. RV. I. 23. 15; II. 40. 3.
2. Ibid I. 95. 3; I. 164. 15.
3. Vide I. 164. 47; VII. 70. 2 and I. 161. 11-12.
4. I. 19. 3-4; I. 165. 1; V. 57; I. 38; V. 53; VIII. 7.
5. RV. VIII. 85. 8 and V. 52. 17.
6. Taittirīya; IV. 4. 12. 3. Vide Vedic Index Vol. II, p. 439.

however, not be unreasonable, if the south-east and south-west monsoons are traced in the Ṛgveda where there is also a better reference to rain bearing winds.[7] The mantra VIII. 7. 14. describes the winds ascending mountains.

Very scientific description of clouds is found in II. 24. 4 "stonelike, solid, down hanging and water-laden." In a verse[8] Macdonell explains the word 'मिह्' to mean mist, with which one cannot differ easily, if the content is taken into account, though at other places मिह् signifies rainfall. Violent gale in the Ṛgveda has been named ध्राजी.[9]

The verse I. 173. 6 states that the atmosphere encompasses the earth. The solar phenomena are associated with the vault of the sky or heaven, while lightning, rain and wind are referred to as occurring in the atmosphere but it is doubtful whether the Ṛgveda knew or guessed exactly the limit or the vertical height of the atmosphere.

In a verse[10] we read "Savitṛ (the sun) encompassing them by magnitude pervades the three (divisions) of the firmament, the three worlds, the three brilliant spheres, the three heavens, the three fold earth....." In this connection a very pertinent question occurs to mind, whether the three divisions of firmament denote troposphere, stratosphere and ionosphere ? Again, in the triple divisions of the earth, are we entitled to identify frigid, temperate and torrid zones, for different schools regarding Aryan home do recognise the Ṛgvedic Aryans' knowledge about frigid and temperate zones and just possible in course of their ocean voyages and advances for habitat they might have known torrid zone also. But it is not possible to say anything conclusively on this point in face of different and frequently discordant interpretations and real obscurity of the hymns.

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7. X. 137. 2; I. 19. 7.
8. RV. VIII. 7. 4. Vedic Mythology p. 161.
9. Vedic Index, Vol. I. p. 405.
10. RV. IV. 53. 5. Vide I. 34; III. 56; I. 108. 9-10; V. 60. 6 and others.

The Ṛgveda clearly asserts[11] that the atmosphere contains dust-particles and moisture or humidity.

The three other Vedas, namely, Sāma, Yajuḥ and Atharvaveda furnish some additional informations on climatology and metereology, which we do not come across in the Ṛgveda. If the theory that these three Vedas chronologically belong to a later period be correct, it can be easily surmised that during this age the two above mentioned practical sciences progressed empirically to a considerable extent.

Like the Ṛgveda the Taittirīya Sanhitā[12] also reveals the knowledge of six seasons. It further mentions "five winds."[13] It is not known what types of winds are indicated by this expression. That rain is the phenomena of ocean, wind and moisture, is proved to be clearly known by this time: "From the ocean, O Maruts, Ye make (the rain) to fall, O Ye that one rich in moisture."[14] Air circulation plays a definite role in the causation of rainfall is stated thus, "Verily becoming of like hue he (wind) causes Parjanya to rain.[15] West wind and the rain bearing monsoon or east wind are spoken of in these lines—"Stay, O Maruts, the speeding falcon, (with these words) he pushes back the west wind; verily he produces the eastwind, to win the rains. He makes offering to the names of the wind, the winds rule the rain."[16]

Those Aryans definitely knew that plants (or forests) had some influence on the causation of rainfall, "Verily it rains from the waters and the plants."[17] The concept and role of insolation is also referred to in the Taittirīya Sanhitā.

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11. Vide Wallis, p. 133.
12. I. 5 1.4 and V. 1.5.2 (Keith).
13. TS. I. 6.1.2.
14. TS., II. 4.8.2.
15. Ibid, II. 4.9.1.
16. Ibid.
17. Ibid, II. 4.9.3.

Agni (insolation) thence causes the rain to arise.[18] The Atharvaveda repeats the same thing.[19] Like the Ṛgveda, Atharvaveda also talks of three atmospheres and three fold earth.[20] This further goes to corroborate the surmise advanced and discussed above that those Aryans were acquainted with the three zones (torrid, temperate and frigid) of the globe and three regions (troposphere, stratosphere and Ionosphere) of the atmosphere

Most probably the following lines of the Sāmaveda express that the earth is heated by radiation and convection currents are formed in the atmosphere—

"This all-moving radiance proceeds from the east, and takes its seat in the mother earth. Afterwards the ever-moving body proceeds to father heaven. Its rays move with man, and from the higher vital air extract and carry down the lower vital air."[21]

The Sāmaveda had begun to make correct guesses about the height of clouds and was acquainted with the fact that clouds ascend and roam in the mountainous altitude also.[22]

In the Vedas at several places mist has been given the appellation of नीहार.[23] The Taittirīya Sanhitā knew about the immense concentration of mist or fog on water, bodies and oceans. "Thou art ocean full of mist." [24]

The Pṛthvī-Sūkta of the Atharvaveda[25] speaks of a violent dusty storm which uprooted trees, and calls it as मातरिश्वा.

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18. Ibid, II. 4.10.2.
19. AV., VII. 107.1 (Whitney).
20. Ibid, XIX. 27.3; XIX. 32.4.
21. SV., XI. 11 p. 149 (Eng. Trans. J. Stevenson). The foot note adds "Or this radiance moves from the heights of heaven to the depth of the earth".
22 Ibid, I. 13. p., 84.
23. Vājasaneyi-Sanhitā, 17.31 and others.
24. Keith, IV. 7.12.3, p. 385.
25. XII. I. 51.

In his introduction to the English translation of the Śatapathabrāhmaṇa,[26] J. Eggeling purports to say that the Vedic literature mythically describes the Indian atmospheric phenomena, specially those of the monsoons and rainy season, and the violent thunderstorms by which they are usually accompanied. Following the Ṛgveda the Śatapathabrāhmaṇa also recognises sixty three winds.[27] The same text calls hoarfrost as प्रुष्वा.

The Taittirīya Āraṇyaka[27a] (latest 800 B. C.) says that there are seven types of air currents or winds in the atmosphere which produce seven types of clouds of the same appellations. These are—1—वराहव, 2—स्वतपस, 3—विद्युन्महस, 4—धूपय, 5—श्वापय, 6—गृहमेध, and 7—अशिमिविद्विष. The वराहव creates circumstances which are responsible for condensation and good rainfall; the स्वतपस is that whose temperature condition is little affected by the insolation or sun and perhaps occurs at a higher altitude and is responsible for precipitation, the विद्युन्महस gives rise to thunderstorm; the धूपय possesses some latent property or aroma which it imparts to the

26. SB., part II, p. XVI.
27. Ibid, part I, II. 5. 1. 13.
27a. I. 9.4-5. and Sāyaṇabhāṣya.

Compare them with RV. II. 12.12. Annotting the latter Prof. Wilson (in his Eng. Tran. of the Ṛgveda Vol. II, p. 316) says "सप्तरश्मि (the word occurring in the Ṛcā) the seven rays, रश्मय: are here said to imply the seven forms of पर्जन्य or Indra, as the rain cloud; or seven kinds of rain clouds, severally named in the Taittirīya Āraṇyaka".

Commenting on the aforesaid Ṛcā, Sāyaṇa remarks, "य: सप्तरश्मि: सप्त-संख्याका: पर्जन्या: रश्मयोयस्य !" Thus this Ṛcā expressed in an anterior period the same geographic fact about winds or air-currents and clouds which is given later in the Taittirīya Āraṇyaka more elaborately and accurately.

objects with which it comes in contact, explaining metaphorically, it may be said to be responsible for the discharge of latent heat of clouds; the श्वाप्य possesses the property of permeating or expanding quickly and the गृहमेध affects the humidity or moisture content of the atmosphere (perhaps Sāyaṇa has not been able to explain it properly). These six belong to a single genus and have a single or similar regions of activity. The अशिमिविद्विष belongs to another genus and its geographical realm or region is different from the preceding six; however, it is highly favourable for agricultural purposes. Sāyaṇa says that these severe winds give rise to seven classes of clouds which bring rainfall.

In I. 10.3 of the same Āraṇyaka two more types of clouds are mentioned, 1—शम्बर or शाम्बर and 2—बहुसोमगी. The former is responsible for profuse rainfall, and the latter is identified by Rajendra Lal Mitra (the editor of the Taittirīya Āraṇyaka) to be "the moving nimbus full of water[27b].

The Rāmāyaṇa

Canto 4 (interpolation) of the book VII of the Rāmāyaṇa furnishes a lot of information regarding the atmosphere, its conditions and cosmic regions upto the distance of the moon from the earth. Here the entire atmospheric cosmic stretch has been divided into nine regions, where the last one is the longest one covering 80,000 Yojanas. The vertical expanses of other regions are also given, but their *fundamentum divisionis* is unknown and most probably they are merely imaginary or guess work. In this connection we may, however, refer, with interest to the modern divisions of the atmosphere and cosmic regions into troposphere, tropopause, stratosphere, ionosphere and various cosmic layers and their most recent studies as carried on by sputniks, man-made satellites, and other astounding space research devices, laser rays and neutrino explorations and quasers known upto 1968.

27b. R. L. Mitra ed. Taittirīya Āraṇyaka, Introduction, p. 17-18.

I. 46 describes mythically the origin of the atmospheric layers. Verse 4 of the following canto also speaks of the seven atmospheric layers or regions (वातस्कन्ध).

Verse VII.4.3 (interpolation) speaks of three kinds of clouds—ब्राह्म (produced from Brahmā), आग्नेय (produced from fire) and पक्षज (produced on a mountain flank--MND renders it wrongly). Nothing can be surmised as to the real and accurate characteristics of these. The phenomena of discharge of latent heat and processes of condensation and freezing in the space are mentioned in verse 9, though its details are inconsistent. The decrease of temperature with the increase of height and unbearably low temperature at an enormous height are alluded to in the verse 19. In a context[28] we read about black clouds bringing rainfall. Ascent of clouds in mountains and rainfall is stated in VI. 69/70. 124[29]. Perhaps this points to the knowledge of orographic factor in the causation of rainfall which we have already come across in the term पक्षज. Intensive insolation and high temperature as an agency of destruction or dispersion of the existing clouds is spoken of in VI. 43.29. White, red, blue and grey clouds are also referred to in the epic.[30]

Again in the Rāmāyaṇa we read about evaporation by the sun's rays in general,[31] about the formation of clouds due to solar heating of the ocean;[32] and about the insolational heating of ocean waters.[33]

Clamatic vaguery or absence of rainfall is referred to in I. 9.9. And I. 22.23. speaks indirectly of atmosphere free from dust, fog, frost and mist. Similarly condition of nocturnal sky (the moon from नीहार or mist) is alluded to in I. 29.25.

Mist and its disappearance through diurnal rise of temperature is referred to in I. 55.25; mist and severe cold in

28. VI. 89 (only occurring in MND p. 1411).
29. MND., p. 1339.
30. V. 1.79.
31. II. 105.20.
32. VII. 4.23; VII. 32.68.
33. VII. 25.30.

III. 16.12; cold western wind made still colder due to the effect of हिम (frost) in III. 16.15; very dense mist in the vicinity of the earth surface in III. 16.23; water vapour hanging on the surface of the river stretches in III. 16.24; dew formation on the sandy margins of the bank in III. 16.24, and snowfall in III. 16.25. Verses III. 16.10-26 give a very good description of winter season with some of its important geographic paraphernalia. Moutain winds or wind of mountain-valleys are also spoken of.[34]

In another verse[35] we read about dry dusty and gusty wind. Later on violent storm or tornado is also mentioned.[36]

The Mahābhārata

In the twelfth skandha of the epic, the atmosphere is divided into seven regions (skandha sphere) and they are discussed in considerable detail. "That wind which is the first in the above number and which is known by the name of प्रवह drives, along the first course, masses of clouds born of smoke and heat. Passing through the sky, and coming into contact with the water in the clouds, that wind shows itself in eflulgence among darts of lightning."[37] "The second wind, called आवह, blows with a loud noise. It is this wind that makes Soma (the moon) and the other luminaries rise and appear."[38] "That wind which drinks up water from the four oceans, and having sucked it up gives it to the clouds in the sky and which, having given it to the clouds, presents them to the gods of rain, is the third in the number and known by the name of उद्वह."[39] "That wind which supports the clouds and divides them into various parts, which melts them for pouring rain and once more solidifies them, which is perceived as the sound of roaring

34. IV. 1.15.
35. VI. 78.19.
36. VI. 106.21 (वाता मण्डलिनस्तीव्राः —) M.N.D. 1475.
37. XII. 329. 36.
38. XII. 329. 37.
39. XII. 329. 38-39.

clouds, which exists for the preservation of the world by itself assuming the form of the clouds... is known by the name of संवह. The fourth is the number, it is gifted with great strength so that it is capable of rending the very mountains."[40] "The fifth wind has great force and speed. It is dry and roots out and breaks down all trees. Existing with it, the clouds are called वलाहक."[41] "That wind.....creates sound in the sky. It is known by the name of विवह."[42] In the sixth परिवह layer takes place illumination through rays and occurs refraction.[43] The seventh परावह layer is perhaps some cosmic region which cannot be resisted by anybody.[44] Here at five places the term "wind" used actually implies a sphere or layer. Secondly these seven names also occur in the Purāṇas and other later literature. Thirdly though these lines proceed to furnish a scientific description, they contain some mythical material also, specially in the analysis of the last sphere. Thus in them we cannot search for very accurate factual data of modern climatology.

Prior to the description of these seven regions of atmosphere in the 6th Parva, we find mention of irregular winds.[45]

The Vanaparva tells us that the sun evaporates moisture from all plants and water bodies and causes rainfall.[46] The epic informs us of four types of clouds—संवर्तक, वलाहक,[47] कुण्डधार[48] and उतङ्क.[49] It has already been said above that वलाहक clouds are formed in the विवह sphere. Clouds bring-

40. XII. 329. 40-41.
41. XII. 329. 42.
42. XII. 329. 43-44.
43. XII. 329. 45-46-47.
44. XII. 329. 48-51.
45. VI. 12. 35 or 36-37.
46. III. 3. 49.
47. VIII. 34. 28.
48. XII. 271. 6.
49. XIV. 55. 35-36.

ing rainfall in desert area are called उतङ्क.[50] These classifications of clouds are different from those enumerated in the Rāmāyaṇa and Purāṇas.

Vaiśeṣikasūtra of Kaṇāda

Kaṇāda explains the cause of evaporation of water thus, "The sun's rays (cause) the ascent (of water), through conjunction with air."[51] Referring to the process of condensation and dissolution of water, he remarks, "Condensation and dissolution, of water, and due to conjunction with fire" (or heat).[52] About the phenomenon of thunder he observes, (Thunder clap results) from conjunction with, and disjunction from, water, of the cloud."[53] Here it is fully evident that the great sage knew that thundering is caused due to impact of positively and negatively charged clouds. He was also acquainted with convection-currents in the atmosphere which he refers to in very scientific terms.[53a] "नोदनापीडनात्संयुक्तसंयोगाच्च." Śaṅkara Miśra (1600 A. D.) has very beautifully explained this and illustrated it with the example of a kettle of water heated from below. It conclusively proves that the great philosopher Kaṇāda (C. 600 to 700 B. C.) knew that the earth is heated by the sun's rays through radiation.

Arthaśāstra

By the time of Kauṭilya, Indians had developed the method and instrumental device for measuring rainfall. This rain-gauge was known as वर्षमान. He describes its construction in these words, "In (front of) the store house, a bowl (कुण्ड) with its mouth as wide as an Aratnī (24 Aṅgulas =18" nearly) shall be set up as rain-gauge (वर्षमान).[54]

50. XIV. 55. 37.
51. 5. 2. 5.
52. 5. 2. 8.
53. 5. 2. 11.
53a. 5. 2. 6.
54. Book II, chap. V, p. 64.

Kauṭilya was acquainted with the distribution of rainfall in various areas. He furnishes a very accurate scientific description of the same with statistics. "The quantity of rain that falls in the country of Jāṅgala (desert-countries) is 16 droṇas, half as much in moist countries (अनूपानाम्) as to the countries which are fit for agriculture (देशवापानाम्); $13\frac{1}{2}$ droṇas in the countries of Aśmakas; 23 droṇas in Avanti; and an immense quantity in western countries (अपरान्तानाम्), Koṅkaṇa, the border of the Himālayas.....".[55] From this it is evident that the spirit of the methodology of the measurement of rainfall given by Kauṭilya is the same as we have today, the only difference is that he expresses it in weight measure while we use linear measure nowadays.

Discussing the further geographical details of rainfall, he observes, "when one third of the requisite quantity of rain falls both during the commencement and closing months of the rainy season and two-thirds in the middle, then the rainfall is (considered) very even (सुषुमारूपम्)."[56]

As can be easily expected, out of the agricultural necessity, the science of forecasting the rains had also come into existence and must have been developing empirically. Regarding it Kouṭilya says—"A forecast of such rainfall can be made by observing the position, motion and pregnancy (गर्भाधान) of the jupiter, the rising and setting and motion of the venus, and the natural or unnatural aspect of the sun".[57]

Discussing the classification of clouds and interrelationship of rainfall and agriculture, the celebrated author adds, "There are the clouds that continuously rain for seven days; eighty are they that pour minute drops; and sixty are they that appear with the sunshine (this is termed rainfall), where rain, free from wind and unmingled with sunshine,

55. R. Shamasastri, Eng. Trans., p. 143.
56. Ibid.
57. Ibid.

falls so as to render three turn of ploughing possible, then the reaping of good harvest is certain.

"Hence i. e. according as the rainfall is more or less the Superintendent shall sow the seeds which require either more or less water."[58]

In modern meteorological treatises several genuses and a large number of species of clouds are rocognised. In such a work ten genuses and forty-five species of clouds are enumerated.[59]

Pāṇini

Pāṇini refers to the rainy season as प्रावृष (IV. 3.26; VI. 3.14) and वर्षा (IV. 3.18); the former was the first part of the season (Hopkins, Epic Chronology; J. A. O. S. 1903, p. 26). These two parts were known as पूर्ववर्षा and अपरवर्षा (अवयवाद्ऋतोः VII. 3.11). He also refers to वर्षप्रमाण (III 4.32), measurement of rainfall, of which गोष्पद is mentioned as the measure of lowest rainfall (VI. 1.145) "[59a]

The Purāṇic Sources

Various Purāṇas inform us that there are seven regions or layers (वातस्कन्ध) in the atmosphere or there are seven types of winds.[60] Little variation is to be found in their names, they are enumerated as प्रवह, आवह, उद्वह, संवह, विवह, परावह and परिवह. The Brahmāṇḍa further says[61] that these have five types of circulation or movement. The Nārada Purāṇa[62] describes them in considerable detail and this

58. Ibid. p. 143.
59. H. R. Byers, General Meteorology, Chapter VI, pp. 107-123.
59a. V. S. Agrawala, India as known to Pāṇini, p. 203.
60. Brahmāṇḍa (Pūrvabhāga), 19.171 ; Vāyu, 49.163 ; Nārada (60.13, 17-35) speaks of seven air channels, (सप्तैतेवायुमार्गाः) or winds ; Kūrma, chap. 41; Matsya—seven winds—163.32-33 ; Padma (Sṛṣti) 42.123-24.
61. 19.172.
62. Nārada Purāṇa, 60. 17-35.

description is mostly geographical. It, however, resembles fully that given in the Mahābhārata, already discussed. It appears that the Nārada Purāṇa has copied it from the epic.

The phenomena of evaporation, cloud formation, classification of clouds and their relationship with winds or regions of atmosphere (वातस्कन्ध) are quite satisfactorily discussed in several Purāṇas,[63] and a full-fledged separate chapter has been devoted in them to these topics, which positively evinces that due importance of this branch of geography or meteorology was realised.

In this connection the Vāyu, Brahmāṇḍa and Matsya deserve special mention. Discussing the general genesis of clouds the Vāyu Purāṇa says[64] that there is moisture content in all the movable or immovable objects of the world and due to insolation or sun's rays evaporation of that humidity takes place (आर्कं तेजोहिभूतेभ्योहचादत्ते रश्मिर्जलम् ॥२३॥) and this process produces clouds. Oceans winds or atmosphere and sun's rays or insolation play the dominant role in giving rains. Winds determine the distribution of the rainfall.

Then the later details in the Vāyu and Brahmāṇḍa are similar.[65] They say that those clouds which give or sprinkle water are called मेघ and which do not bring any rainfall are known as अभ्र. There are three types of clouds १–आग्नेय, २–ब्रह्मज and ३–पक्षज As the following descriptions reveal, these are connected with cyclonic (thermal and insolational), convectional (occurring in northern continents, Siberia and equatorial regions) and orographic (occurring and proceeding from mountain flanks) types of rainfall respectively.

According to the above mentioned two Purāṇas, Āgneya occurs in the winter season and it assumes the forms of

63. Brahmāṇḍa, chapter 22 ; Vāyu chapter 51; Liṅga chap. 54; Matsya chap. 125.
64. 51.22-25. The Liṅga specifically recognises the role of forests also in the cloud-formation. (54.40).
65. Vāyu, 51.26-40 and Brahmāṇḍa, 22.30-43.

buffalo, boar and elephant ; it is devoid of lightning and thunder and is of immense expanse and found in mountain foots also It brings rainfall within a radius of a mile or two. This description approximates most to the Nimbus of modern days. The Brahmaja clouds are produced due to respiration of Brahmā, perhaps symbolically implying convection currents. These have lightning and send out deep rumbling. In precipitation they cover an area or radius of nearly a yojana (Five or eight miles). Most probably these are cumulonimbus. The Puṣkarā-vartaka clouds originate from or in the wings of mountains (पक्षसंभवा). They assume various forms and produce deep rumbling sound. They are full of profuse water and bring excessive rainfall which is extremely destructive. This description conforms to a large extent to the modern class of altostratus.

The Matsya Purāṇa[66] furnishes still more elaborate and scientific information regarding clouds. It says that the clouds जीमूत beget life. Those clouds remain suspended on the air Āvaha. They change shape and going up a yojana[67] from there form into rain hence they are called the source of rain. The clouds पुष्करावर्त have been born from the wings of (mountains). These wings are named पुष्कर and hold a huge volume of water hence the clouds are known as पुष्करावर्त..... These clouds assume various forms, give out thundering noise, produce deluge of rains.....The bursting of Brahmā's egg produced other clouds called मेघ. Without distinction their chief source of nourishment is smoke. The most important of those clouds is पर्जन्य. If the ślokas 17, 18 and 19 are interpreted symbolically, they give other four classes of clouds expressed by the nomenclature गज, पर्वत, मेघ and भोगी. Then in the verse 17 can be recognised further four classes of गज clouds.[68]

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66. Ch. 125.
67. Eng. Translation is S. B. H., Vol. XVII.
68. The above translation, however, gives the ordinary meaning.

To the north and south of the snow-clad mountains (हिमवत) occurs the पुष्ड्र cloud which greatly increases the stock of rain. All the rain formed there converts itself into the snow. The wind on the हिमवत् draws by its own force those snow flakes and pours them on the great mountains. Beyond the हिमवत् there occurs little rain.[69] Thus here is a reference to a very important geographic fact of scanty rainfall or arid condition of the Tibetan plateau. The study and knowledge of this fact is really creditable on the part of those ancient Indians.

Next to it is another cloud named इभ that helps the growth of beings. These two clouds, enhance the amount of rains.

The Skanda Purāṇa says,[70] "It is the प्रवह wind or air current which makes the clouds produced by smoke and thermal activity, full of water, so that the clouds taking blue colour give copious rainfall".

Processes of condensation and precipitation on hygroscopic nuclei are very carefully described in nut-shell, thus,[71] "The waters from the (vapours) of the clouds when brought into contact with the wind (*namely hygroscopic contents of the air*) fall in the shape of rain."

The Viṣṇu Purāṇa very scientifically enumerates the four sources of atmospheric moisture, "The glorious Sun, O Maitreya, exhales moisture from four sources, namely—seas, rivers, the earth and living creatures".[72]

Knowledge of the mountainous rainfall is further revealed by the line "वृष्ट्यर्थं जलदास्तत्र प्रभवन्ति चयान्ति च."[73] The next verse reveals that mountainous flanks receive copious rain "यतोनित्यमुपादत्ते वासवः परमं जलम् ।"[74]

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69. Matsya, 125.20-25.
70. Maheśvara Khaṇḍa. (Kumara Khaṇḍa) 38.58.
71. Matsya, 125.33.
72. II. 9.11.
73. Brahmāṇḍa, 19.85.
74. Ibid, 19-86.

Modern meteorology tells us that polar winds actually never bring any rainfall in the year in the regions under their influence—flanking poles or Tundra, and only scanty summer rain occurs in those areas due to the sweeping of strong westerlies. The same fact is stated in the Puranic line, "ध्रुवेणाधिष्ठितो वायुर्वृष्टिं संहरते पुनः"-the air from the pole drives away the rain".[75]

The celebrated poet Kālidāsa (100 B.C.) also knew a lot about clouds and the allied phenomena. He defines cloud thus, "it is an assemblage of smoke, electricity, water and air".[76] He has spoken of thunder-storms several times in his works.[77] At two other places the poet names two types of clouds—पुष्कर and आवर्तक.[78]

The Mṛicchakaṭika (600 A.D) refers to a kind of cloud द्रोण[79] from which the rain streams forth as from a bucket. In other context the famous drama refers to a special type of rain "द्रोणवृष्टि" streaming forth as from a trough.[80]

In this classification four types of clouds in all have been spoken of. They are आवर्त, संवर्त, पुष्कर and द्रोण. The Āvarta brings no rainfall, the Saṁvarta gives abundance of rain, the Puṣkara causes deluge of rain and the Droṇa is most congenial to agriculture and mankind. This is stated in nutshell in the following lines—

आवर्तो निर्जलो मेघः संवर्तश्च बहूदकः।
पुष्करो दुष्करजलो द्रोणः शस्यप्रपूरकः ॥[81]

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75. Matsya, 125.36.
76. Pūrvamegha, verse 5 and also Uttaramegha, verse 66 (विद्युद्वन्तम्).
77. For example Raghuvaṁśa, 14.62.
78. Kumārasambhava, II. 50 and Pūrvamegha verse 6
79. Mṛcchakaṭika X. 25.
80. Ibid, X. 37.
81. Quoted in the Kālidāsa Granthāvalī अभिधानकोष, p. 137, but the verse must belong to an era prior to or near about 1200 A.D.

Jyotiṣa Works :

The Vṛhatsanhitā and Mayūracitraka by Varāhamihira are two very important treatises which are replete with climatological and meteorological informations. Though they abound in astrological guesses, they contain sufficient scientific facts also.

In the Vṛhatsanhitā there are three chapters (21st, 22nd and 23rd) on climatology and meteorology and they treat these subjects in their own ancient conventional style. Here only the salient features of the chapters are being surveyed.

Verses 23 and 24 of the chapter xxi state that extremely white or dark clouds resembling aquatic animals like huge fish, shark or tortoise and seen before the rainy season are a source of abundant rainfall. Verse 31 discusses the conditions or meteorological ingradients which determine the spatial expanses of rainfall, though it appears to be of little value from modern meteorological point of view.

From chapter xxii it is gathered that fleecy and thick clouds give abundant rainfall which is very congenial to agriculture. Again if clouds situated in the east, south and north sail towards south, west and north respectively, they cause fine and copious shower.

Like Kauṭilya and other precursor authorities, Varāhamihira also describes the device of the father of the raingauge and tell us how to measure rainfall from it. In verse 2 of chapter xxiii, he states that constructing a circular bowl (कुण्डकम्) measuring one cubit, one should tell the amount of rainfall. For this purpose rain-water received in the bowl during the actual falling should be measured. The distribution of the rainfall according to time is discussed in the verses 6, 7, 8 and 9. These verses specify amount of rainfall in various lunar mansions.

In calculating rainfall Varāhamihira adopts weight measure of *pala*, *droṇa* and *āḍhaka*.[82] In chapter xxxv, he

82. 4 आढक = 1 द्रोण = २०० पल and one आढक equals nearly 7 lbs. 11 ozs. avoirdupois.

says that phenomenon of rainbow is the result of spectro-analysis of sun's rays through clouds in the atmosphere.[83]

In the Mayūracitraka it is stated that scattered clouds devoid of lightning are harmful to people and those of red or white silken or golden or Krauñca bird's hue, embedded in the atmosphere and fleecy in texture are always beneficial to the people.[84] Causation of fog or mist in Pauṣa (December-January) is conducive to good rainfall.[85]

Discussing the conditions determining rainfall, it says that if there is no frost in Māgha (January-February), no vigorous wind in Phālguna (February-March), no clouds in Caitra (March-April), no hailstorm in Vaiśākha (April-May) and no scorching heat in Jyeṣṭha (May-June), there is insufficient rain in the rainy season.[86]

If the sun is hot in the morning, its light during the day is of yellowish hue and clouds are fleecy and dark-coloured, the conditions result in good rain. Similarly if the sun is hot in the morning or at the time of rising and scorching at noon and clouds have a pigment of molten gold, rain occurs during the very day.[87]

If water appears to be dull, clouds are of the shape of mountain, quarters are clear, the sky is of the hue of crow's egg, there is lull or calm in the atmosphere and aquatic animals like fish and others disappear in the bottom and frogs make loud noise, very fine and copious rainfall comes soon.[88]

Further if the texture of clouds resembles the wings of a partridge, rainfall occurs positively.[89]

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83. 35. 1.
84. Verse 4 5, p. 66.
85. Verse 84, p. 64.
86. Verse 22, 23, p. 100-101
87. Verses 39-40, p. 106
88. Ibid, verses 41-42, p. 108
89. Ibid, verse 48, p. 110

Thus it is evident that the Mayūracitraka has attempted to formulate principles for forecasting rainfall through the observation of natnral phenomena and the synchronisation and correlationship of the two. The symptomatic synchronisation in the realm of nature is often governed by laws having mathematical accuracy in which intuition of the animate (birds and the animals) and scientific cause and effect relationship of events form the chief *raison d'etre*, provided the observation has been made very carefully. In those ancient days, when advanced meteorology and its complicated computations, computors and other cybenatic and servomechanic contrivances were unknown this was of special significance and most probably the only method. The other akin treatises also establish this assertion.

The Adbhuta Sāgara is no negligible repository of climatological and meteorological knowledge. It quotes profusely from very older authorities like Vṛddha Garga, Garga, Bhārgavīya, Parāśara, Kāśyapa, Devala, Varāhamihira and others. Here all the following quotations are from the Adbhutasāgara.[90]

"The wind designated विष्वग् blows furiously from all quarters and makes the whole area extremely dusty." "A dust storm blows violently uprooting trees." (भीष्मपर्व-Mahābhārata). "Impetuous wind blows scattering dust making terrible sound, sending long trails and highly agitated by clouds and at various places being converted into whirlwinds" (Uttarakāṇḍa—Rāmāyaṇa).

Garga and Parāśara refer to climatological effect of winds blowing from various quarters. Giving a little more detail, the latter says, "Easterlies give rise to clouds. Westerlies create turbulence in the sky and annihilate clouds. Northerly always causes rain. Southerly creates the congregation of clouds or gives light rainfall.....southwest and north-west winds are full of clouds and bring excessive rain. The northeast wind, though mild, brings rainfall. When

90. pp. 353-359

there is a confusion of various winds, it produces excessive rain."

The Udyogaparva of the Mahābhārata speaks of the southwest wind as a great uprooter of the trees and producing very harsh and terrible sound.

The Bhārgavīya discusses the relationship of various colours of clouds and rainfall. White, dark, green, black and twilight hued clouds bring copious rain. Clouds having the hue of Campaka flower also bring rain. Those possessing opposite colours may be apprehended to antagonise rainfall. If clouds possessing the hue of the peacock throat, lotus, moon, bronze and lily flower (blue in colour) appear in the evening, it gives rise to immense rain.

The Mayūracitraka says that thick clouds resembling lotus leaves and shadowing the sun and the moon give plenty of rainfall. This description perhaps refers to the cumulonimbus clouds.

Clouds having their fore-fronts like curd and resembling a tree in shape and those yellowish and checquered also cause rain. These resemble the nimbo-stratus most.

Sage Parāśara gives the quantity of rainfall received in various lunar mansions[91] and discusses its geographical influence on agriculture. Devala and Garga have tried to delimit the areas of rainfall also. Devala says that under a specific condition it rains within an area of 10 yojanas in the rainy season. From Garga we gather that after the advent of rainy season Indra gives rain in an area of 12 yojanas.

Parāśara knew the contrivance of primitive rain-gauge and method of measuring the quantity of rain received.[92]

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91. Pravarṣaṇādbhutāvarta, p. 373-74

92. आढ़काञ्श्चतुरो द्रोणानपां विद्यात् प्रमाणतः ।
धनुः प्रमाणं मेदिन्यां विद्याद् द्रोणाभिवर्षणम् ।।
चतुर्विशाङ्गुलानाहे द्विचतुष्काङ्गुलोच्छ्रिते ।
भाण्डे वर्षाम्बुसंपूर्णे ज्ञेयमाढकवर्षणम् ।। (*Adbhutasāgara*, p. 375)

The quotation from the Mayūracitraka occurring in the Adbhutasāgara gives various sizes of hail.[93] It alludes to hail of the sizes of plum, wood apple, mango, fig and other objects. It refers to some absurd sizes also.

Apart from the material analysed above, the Adbhutasāgara contains more of it, but it is generally irrelevant or absurd from scientific point of view, hence no discussion has been envisaged on that part of information.

The Meghamālā

The author of the present dissertation, in course of his researches and search for manuscripts on geography proper, has come across a manuscript treatise entitled मेघमाला. As the very name suggests, it is a work on climatology and meteorology. Though it aspires to be a scientific work, actually in general form, matter and spirit, it is a medlay of climatology, meteorology, astrology, science of pre-vision and imaginary facts. It, however, entails upon us a survey and an appraisal of its contents ; as it is an old attempt, in a very right and important direction, to dilate on an extremely essential branch of geography.

A word about the work and its date. The present author has examined nine manuscripts of the मेघमाला kept in the Saraswati Bhavan of Vārāṇaseya Sanskrita Viśvavidyālaya. He has also known a printed edition of the text, but unfortunately it could not be available for the study. So here the investigation is based on the study of Mss. only.[94]

Everywhere in the colophone occur the expressions "रुद्रयामले" and "उमामहेश्वरसंवादे" which appears to indicate that the work forms a part of रुद्रयामलतंत्र. Its dialogue form

93. Ibid p. 377.

94. The present author intends to prepare a critical edition of the मेघमाला with an introduction and scientific analysis of its contents at some later convenient time, though the work has already made some headway. There is a Jain work or version of the same name, but of much later date.

of style also corresponds to that of the रुद्रयामलतंत्र though in the latter भैरव and भैरवी occur instead of उमामहेश्वर. Still it is not found in the aforesaid Tantra, as the latter is available to us.[95] Assuming, however, that the मेघमाला formed a part of the रुद्रयामलतंत्र, it should not be placed earlier than 900 A.D. which is the date of the latter text. In one of the Mss. of the मेघमाला, examined by the present researcher, the date of the copy is given to be 1824 A.D. Naturally, therefore, it must have been written between 900 and 1824 A.D. In Chapter IV of the मेघमाला occur names of towns Yavanapura (verse 6) Candela (verse 19) and Bījāpura (verse 85). On this internal evidence it appears that it was composed or redacted not earlier than the beginning of the mediaeval period (1200 to 1400 A.D.). The Meghamālā actually anticipated Ghāgha and Bhaḍḍarī in U.P. or northern India and Khana in Bengal.

Now we come to the survey of the contents of the text. There are eleven chapters in the book. The first chapter opens with the enquiry—

"मेघस्तु कीदृशादेव कथं विद्युत्प्रजायते ।
कीदृशं वर्णरुपं तु शरीरं तस्य कीदृशम् ।।

What are clouds, how is lightning produced, what are nature, texture, ingradients and colours of clouds ?"[96] Then clouds are classified into four types, 1—Brāhmaṇa, 2—Kṣattriya, 3—Vaiśya and 4—Śūdra. The Brāhmaṇa clouds appear in the forenoon and have white colour and the Kṣattriya, at the noon with red or brownish colour. The Vaiśya clouds occur in the afternoon and are of yellow hue, while the Śūdra ones appear after the sunset and have dark colour. Clouds of mixed colours are Vipra-Cāṇḍāla.[97]

The above mentioned four species of clouds send out four distinct types of rumbling, namely, sweet, drumlike

95. Published from Calcutta.
96. I. 7.
97. I. 10-12.

sound (गुमगुम), deep-sound and tomtom (ठमठम) respectively.[98] Then in the verses 15 and 16 clouds are said to possess six colours—white, red, yellow, black or dark, bronze and copper colour.

Later in the verses 20, 21, 22 is expressed, in the conventional Indian style, that the mountains control clouds. From verses 32 to 68 we gather that there is a larger division of clouds comprising twelve species and designated as १—सुवुध, २—नन्दशाला, ३—कन्यद, ४—पृथुश्रवा, ५—वासुकी, ६—तक्षक, ७—विकर्त, ८—सारवत् ९—हेमकाली, १०—जलेन्द्र, ११—वज्रदंष्ट्र and १२ विष्णुप्रभ. But no scientific detail of these is furnished. In the following passages is described the economic condition of plenty or scarcity synchronising with each of these clouds.

The chapter II enumerates sixty types of years, refers to their rainfall, and discusses the economic characteristics or conditions of each of them. The third chapter dwells on astrological influence on rainfall, climatology and economic condition of people, state of plenty and scarcity and production of various crops.

The following four chapters have nothing scientific worth mention. The eighth chapter aspires to discuss the nature of rainfall and other meteorological conditions in the twelve months of the year, but is only involved in astrological mesh and generally appears to have failed miserably in its scientific mission. About the Kārtika month (October-November) the author says that during this month scattered clouds of variegated colours occur.[99] In Pauṣa (December-January) if sky is overcast with clouds, it is a very good symptom. In verse 18 (about the same month) another class of cloud named ऐरावत is mentioned. If the month of Māgha (January-February) is not normally cold (or has no frost) there occurs rainfall in southwest in Jyeṣṭha (May-June). In Phālaguna (February-March) northeast wind brings good downpour.

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98. I. 13.
99. VIII. 20.

In the following chapter there is a dilation on clouds, winds and lightning. Firstly it discusses the correlationship of rainfall with different shapes of clouds. Here clouds are said to assume forms of elephants, lions, deer, mountains and crocodiles. Then we are told that northeast wind is conducive to prosperity, southerly does good to people, south-west wind causes misery, westerly is much beneficial for the higher production of rice, northerly is also propitious to the good of people, and it produces a condition of plenty.

The chapter ten deals with the propitiation of clouds and apart from repeating the twelve species of clouds, already mentioned, adds another classification of the same comprising seven species designated as अम्बुद, गोलक, गिरि, आरोपक, सपर्वत, खिखिन्द and कोटिवार.

The last chapter attempts to correlate the nest-building of crows in various directions with the occurrence of rain and its accompanying circumstances. It is mostly occult prevision or astrological.

Kalhaṇa in his Rājataraṅgiṇī speaks of mountain wind.[100] He was also acquainted with mountain-valley wind "कटकानि:सृतात्यल्पा वात्येव गिरि गह्वरात्" "like the wind from a hill gorge".[101] He further mentions ".....hailstones driven by the eastwind" (वर्षोपलै: पुरोवातप्रेरितै:).[101a]

The encyclopaedic Tāntric literature does not lag behind in supplying various information on geography. From the Tantrāloka of Abhinavagupta, we can cull out some important climatological and meteorological facts.

In its Āhnika designated as देशाध्वप्रकाशन[102] are described winds, clouds, track of winds and the allied phenomena. This Āhnika mentions seven regions of atmosphere (सप्तमारुत-स्कन्ध)[103] which is merely a perpetuation of the Brāhmaṇic

100. VIII. 2763 Stein.,(शृङ्गानिल).
101. Ibid, VIII. 255.
101a. Ibid, VIII. 1753.
102. Vol. V. of the Tantrāloka (Indian Press).
103. Ibid, verse 147 p. 110.

geography. But prior to that it refers to ten air channels (वायुपथ) which are perhaps peculiar to only this text. Those ten air channels are १—विवत, २—ऋतर्द्धि, ३—वज्राङ्क, ४—वैद्युत, ५—रैवत, ६—विषावर्त (दुर्जय), ७—परावह, ८—आवह, ९—महावह, and १०—महा-परिवह.[104] These are arranged in space according to increasing height. The outstanding Tāntric work recognised eleven types of clouds १—मूकमेघ, २—प्राणिवर्षी, ३—विषवारिवर्षी, ४—स्कान्द, ५—मारक, ६—संवर्त, ७—ब्राह्म, ८—पुष्कर, ९—जीमूत, १०—ईशकृत्, and ११—महेशिकृत (कपालोत्थ). These types occur according to the increasing height. It is perhaps for the first time in Indian literature that we find in this work special, cogent and logical allusion to the heights of clouds. It is praise-worthy even if it be merely an attempt, right or wrong, to represent a scientific fact. It reveals at least a knowledge of the notion that different clouds occur at different levels in the atmosphere.

The other important notable point is that a few of the above mentioned names of clouds are common to Brāhmaṇic technical terminology, for example, संवर्त, ब्राह्म, पुष्कर and जीमूत which have already been discussed at their proper places in the present monograph.

It appears that Śrīpati, the famous astronomer, elaborately wrote on the topics under discussion. In his edition of the Siddhāntaśiromaṇi, Bāpū Deva Śāstrī has quoted several verses[105] from Śrīpatī on climatology and meteorology. In one of the verses quoted, the latter has recognised the traditional seven atmospheric regions (वायुस्कन्ध).

In the same context Bāpūdeva Śāstrī quotes two verses on hail formation, perhaps they are Śrīpati's, as the former has not clearly mentioned their authorship. They are, however, fully scientific. About the formation of hail they say that when through the agency of vigorous wind, particles of dust, gases and other materials reach the level of cloud (that

104. Ibid, verses 121-138
105. Golādhyāya, p. 262

is considerable height) they are mixed with water particles (contained in the atmosphere) and, solidified like pebbles, fall on the ground. From these lines it is clear that their author had some conception of hygroscopic nuclei and of part played by altitude in condensation or freezing of water particles floating in the atmosphere.

Further three verses quoted by Bāpūdeva Śāstrī, and belonging perhaps to an era prior to 1200 A.D., provide scientific details of the phenomena of fog or mist (for which the term रज: संहति has been used). The verses purport to say that at the end of rainy season dissipated clouds (moisture) hang near the surface of the earth and eclipse mountains, trees, vegetation cover or gardens and disappear through the activity of air of the ground.

In the Madhyagativāsanā (verse 1 and 2) of the Siddhānta-śiromaṇi, Bhāskarācārya simply touches upon a few climatological facts. He speaks of the seven atmospheric regions. But names of these regions given by him are slighty different from the traditional ones. He calls the first stratum "भूवायु" and says that it extends upto a height of 12 yojanas (90 miles) and is the region of clouds and lightning. It is really wonderful how Bhāskarācārya could determine the vertical height of atmosphere (for practical purposes) with considerable accuracy.

Jain Contribution

The Jainas have made the most outstanding contribution in the field of meteorology, which is perhaps unparalleled not only in the ancient history of sciences in India, to be found in none of the prior or posterior Sanskrit, Prākṛta and Pālī literature, but also in the whole world. Their methodology of treatment of some of the meteorological topics also is of unique value in tracing the evolution of the particular science, in so far as it not only presents and discusses the author's view only, but dissects and examines various theories also current by that time on the particular topics. Here in the preceding

sentence, the author of the Sūryaprajñapti is specifically meant, who must have definitely flourished before 400 B.C.[106]

The celebrated treatise Sūryaprajñapti has dwelt at length on insolation, radiation and reflection of the sun's light and energy and heating of the earth and various surfaces, the subjects so essential in meteorology. It really extorts our admiration, when we see that the treatise elaborated so perspicuously and accurately, at such an early period, on (or was at least acquainted so accurately with) the topics which have been taken up, studied and advanced so recently. Its conception of and contribution to "albedo" appears to be something wonderful, when we take into account the fact that the work was composed at least nearly half a millenium B.C. (Here the wrong conception of two suns and two moons of the Jainas is immaterial.)

In Prābhṛta, 4, Sūtra 25, are discussed the range of insolation or heat of the sun (तापक्षेत्र) and in this connection various figures are also given, but it is all incorrect in its very inception and also due to the assumption of two suns.

Prābhṛta 5, Sūtra 26 (designated as लेश्या प्रतिहति,[107] reflection of son's light), enquires into the phenomena of scattering of the sun's light, radiation, insolation, reflection and albedo and gives accurate scientific details. First it mentions twenty theories on the reflection of the sun's light held by the adherents of other sects (परतीर्थिकानाम्.). These are not actually theories but twenty types of surfaces which reflect light or insolation. In this list several of the surfaces are merely repeated or similar. In it are, however, mentioned these surfaces—mountainous or rocky space, very clear and lustrous surfaces, and quarters. In discussing the twenty surfaces the author of the Sūryaprajñapti reveals that he was conscious of the repetition of the similar surfaces and has reduced them to sixteen. Then the aphorism refers to another important

106. Cf. Winternitz, History of Indian Literature, Vol. II, p. 476, Footnote 2.

107. Here it implies reflection, deflection and diffusion.

fact, that unseen (invisible) objects also possess reflective capacity.[108]

Prābhṛta 6, Sūtra 27 investigates the nature or condition of heat, energy or light of the sun (ओजस्थिति). It first gives the old twentyfive theories regarding it. The first theory states that every moment sun's energy is being received, and every other moment it is disappearing. Then the statement is repeated with reference to other 24 measures of time.

But these do not reveal the full story of solar radiation clearly and accurately, however, as an initial attempt they deserve credit.

Then presenting his own point of view the author (of Sūryaprajñapti) says that when at the end of the solar year the sun remains in the innermost circle, on the longest day, its maximum energy comes to prevail for a duration of 30 muhūrtas, after that the sun starts to shift.[108a] Further discussion furnished by him on this point establishes that a confusion must have prevailed in his mind due to his fostering of the belief that there are two suns. From all this, however, one thing is clear that he knew and accepted the theorem of gradual increase and decrease in the amount and duration of incoming solar radiation or insolation.

In aphorism 30 of the Prābhṛta 9 are discussed the nature of convection and radiation heating through the sun's rays with reference to earth's surface and its objects and atmosphere and its contents.

The author of the Sūryaprajñapti first presents the three older theories in this connection, of which only the first is correct and other two are erroneous. The first theory propounds that the objects or matters (पुद्गल) on the surface of the earth are directly heated by the falling of sun's rays (radiation) on them and then other objects (out side them

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108. Vide Byers, General Meteorology, p. 25.

108a Vide, Prof. A. Weber, "Ueberdie Sūryaprajñapti", *Indische Studien*, Vol. X, 1868, p. 282.

in the atmosphere) are heated through their agency (convection). The second confused and absurd theory avers that objects are not heated by the falling of the sun's rays on them nor is through their agency anything else (in the atmosphere) heated. The third has simply mixed the afore-said two and says that some objects are heated by the falling of the sun's rays on them and some are not heated, and thus the former can heat outside objects (in atmosphere) through their agency, while the latter cannot.

The sum and substance of the following aphorism is that slanting rays of the sun give lesser heat and vertical ones greater heat. This is discussed clumsily with reference to the rising of the sun, noon and evening and different places (or latitudes).

In the Tiloya Paṇṇatti[109] also the topic of the range of the heat or insolation (तापक्षेत्र) has been touched upon, but it provides no information worth-mention.

In the Tattvārthādhigamasūtra[110] there are mentioned three Vātavalayas, घनोदधिवातवलय (sphere of thick watery wind), घनवातवलय (sphere of thick wind) and तनुवातवलय (rarified air sphere). There appears little doubt that these represent troposphere, stratosphere and ionosphere.

The Prajñāpanā and Āvaśyaka Cūrṇīs provide outstanding studies of the various types of winds. This tradition must have been far older than these treatises. In this respect also, in the studies and classification of winds, the Jainas are unparalleled in the entire history of geographic science in India. The Prajñāpanā[111] gives the following nineteen types of winds, 1-4 winds of four quarters; 5-6 descending and ascending convection winds, 7—horizontal winds, 8—विदिग्वात (which blows from various quarters), 9—वातोद्भ्रम (irregular winds), 10—वातोत्कलिका (winds resembling those

109. 7. 293-311; Vide प्रज्ञापना-लेश्यापदम्, chapter 17.

110. Chapter III, Sūtra and its commentary by Akalaṅkadeva.

111. I. 18 (पूर्वार्द्ध).

of ocean), 11—वातमण्डली (confused winds), 12—उत्कलिकावात (mixed winds), 13—मण्डलीकावात (whirl winds), 14—गुञ्जावात (rumbling winds), 15—झंझावात (violent wind blowing to the accompaniment of rainfall), 16—संवर्तकवात (wind of particular region mixed with dry vegetation, 17—घनवात (intensive wind), 18—तनुवात (rarified permanent wind) and 19—शुद्धवात (gentle wind).

Āvaśyaka Cūrṇīs furnish a list of sixteen winds,[112] 1—प्राचीनवात (easterly), 2 - उदीचीन (northerly), 3—दक्षिणवात (southerly), 4—उत्तर पौरस्त्य (northerly blowing from the front), 5—सवात्सुक (perhaps undefined); 6—दक्षिण पूर्वतुंगर (southerly strong wind), 7—अपरदक्षिणवीजाय (blowing from the south-west), 8—अपरवीजाय (westerlies), 9-अपरोत्तरगर्जन (north-westerly hurricane), 10—उत्तरसवात्सुक (unknown), 11—दक्षिणसवात्सुक, 12—पूर्वतुंगर 13—14—दक्षिण and पश्चिमवीजाप, 15—पश्चिमगर्जभ (western storm), and 16—उत्तरीगर्जभ (northern storm). Later in the same continuation tornadoes are referred to as कालिकावात. This vocabulary[113] had influenced the Arabian geographers and navigators and they readily absorbed several of these Indian technical terms in their own language.

The *Jīvavicāra*[114] names 1—उद्भ्रामकवात (blowing with dry vegetation), 2—उत्कलिकावात (blowing spasmodically or intermittently), 3—मण्डलीकावात, 4—मुखवात 5—शुद्धवात and 6—गुञ्जवात.

The Prajñāpanā refers to snowfall (हिम) and hailstorm (करक)[115]

The Jambūdvīpaprajñapti[116] gives two classifications of clouds. The first names seven types of clouds thus : १—अरसमेघ, २—विरसमेघ, ३—क्षारमेघ, ४—खात्रमेघ,

112. 9-7/913
113. Vide Motichandra, *Sārthavāha* (Hindi), p. 202.
114. Verse 7. leaf 6
115. I. 16.
116. Vakṣaskara, 2, leaf 150.

५—अग्निमेघ, ६—विद्युन्मेघ, and ७—विषमेघ (अशनिमेघ). The second enumerates १—सक्षीरमेघ, २—घृतमेघ, ३—सघृतमेघ, ४—अमृतमेघ, ५—रसमेघ, ६—पुष्करमेघ, and संवर्तक. They are not properly defined in the text and appear to have no scientific fundamentum divisionis.

The Trilokasāra[117] of Nemicandra says that there are seven types of कालमेघ (periodic clouds or specific clouds, most probably the former). They rain for seven days each in the rainy season. Then there are twelve species of white clouds designated as द्रोण, they also bring rain for seven days each. Thus the season of rainfall extends over 133 days in all.

Malayagiri[118] in the commentary of Jīvajīvābhigama speaks of dew, snowfall, hailstorm and fog or mist.

Buddhist Contribution

In the narrative of the first Jātaka, named Apaṇṇaka, we come across a few climatological facts which are expressed thus, "We have been just told...that it is raining just ahead in the belt of forest, now how far does a rain wind carry ? "A league, Sir....."How far off can you see the crest of a storm cloud". "A league sir".

In the Jātakas[119] two violent storms are mentioned as कालवात (Black wind) and वेरम्भवात. The latter is said to belong to the upper air.[119a] The Sumeru mountain was frequently visited by a violent hurricane (उप्पाटनवात or हरणवात).[119b] It resembled whirlwind in movement. In the Milindapañho hot wind or Loo is spoken of as वातातप.[120] Āryasūra names

117. Passage 679, p. 280.
118. Pratipatti, I, leaf 25.
119. Cowel, Eng. Trans., Migalopajātaka, Vol. III, p. 164. Text, Fauscball, p. 256. Also Gijjha Jātaka No. 427.
119a. Saṁyutta Nikāya, Eng. Trans., XVII. 1-9. p. 157.
119b. Mahāmorajātaka, No. 491, p. 333; Harit Jātaka, No.431, p. 497.
120. Eng. Tran., Vol. II, IV. 6.35, p. 86.

four types of winds—नियतानिल (the monsoon),[121] चण्डानिल[122] (tempest), उत्पातवात (hurricane)[123] and पाश्चात्यवायु or the westerlies[124]. Another wind referred to by him is निर्घातभर[125] (violent hurricane). It cannot be surmised with certitude whether in the following extract from the Milindapañho,

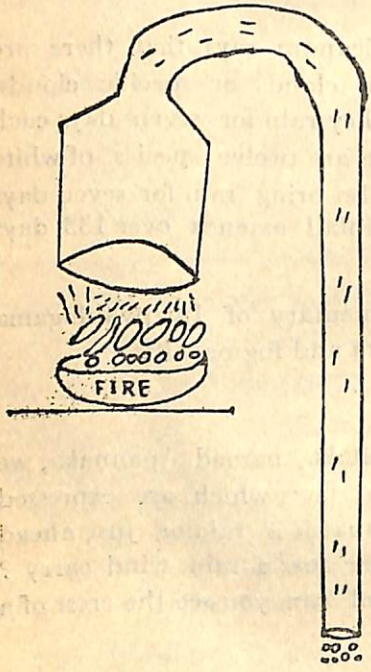

Fig. 2

The ancient Āyurveda Putapāka-Putayukti or Kācavakayantra (referred to by Caraka, Suśruta and other Āyurveda writers). It is Bhabhakā of modern Āyurveda specialists.

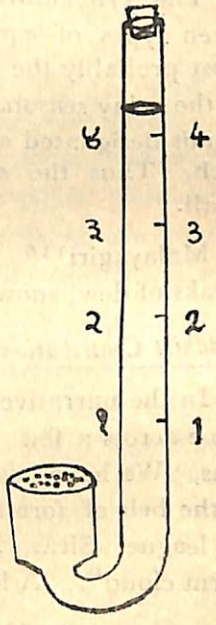

Fig. 3

Buddhist's Waterpot (Dharma-karaka) Barometer—an ancestor of Torricellian Barometer.

Ancient Āyurveda also confirms the existence of this sort of pot (various types of Kāchakupies used for distillation). Technically those pots were called Putapāka or Putayukti. Now-a-days Vaidyas call it Bhabhakā. It is illuminating to note that modern Retort was called Kācavakayantra.

121. Kern ed., Jātakamālā, 10.29.
122. Speyer, English Trans., p. 127.
123. Speyer, op. cit. p. 127.
124. Kern, Jātakamālā, p. 90.
125. Ibid., p. 94; Speyer, op. cit., p. 133.

some ancestor of modern barometer is described or any other instrument. "Then the elder brought in a regulated water-pot (धर्मकरकेन वाधर्मकरकेण) and convinced king Milinda, saying ! "As this water is supported by the atmosphere, so is that water supported by the air".[126]

In the Vinaya Piṭaka[127] whirlwind is called "वातमण्डलीका" and Jātaka (Nidānakathā) names it as वातमंडल.[128] The Divyāvadāna speaks of some kind of hurricane as कालिकावात[129] and of storm accompanied by rain as वातवर्षम् .[130] The unedited portion also of this text contained facts about climatology and meteorology.[131]

The Milindapañho[132] says that there are four types of rainfall : 1-of rainy season, 2- of winter, 3-of the two months Āṣāḍha and Śrāvaṇa (July and August) and 4-a rain out of season. At a glance it can be seen that the classification is fully scientific.

The Buddhists refer to two general classes of clouds, कालमेघ (monsoon cloud)[133] and अकालमेघ (storm clouds or accidental ones).[134] Here the two references in themselves make it absolutely unambiguous that the expression कालमेघ does not have the Puranic meaning "clouds of dissolution".

The Saṁyutta Nikāya classifies[135] clouds into five categories, 1-cool clouds (शीतवलाहक), 2-Hot clouds (उष्णवलाहक), 3-thunder clouds (अभ्रवलाहक Mrs. Davids

126. Davids, English Trans., III. 5., p. 106.
127. Davids and Oldenberg, Cullavagga, Eng. Trans., Vol. III, V. 9.4, p. 85.
128. Vol. I, p. 72.
129. Cowell and Neil ed., Vol. II., p. 41.
130. Ibid, p. 163.
131. Ibid, p. 649-50.
132. Eng. Trans., IV. 1.36.
133. Mahāvastu, Eng. Trans., Vol. II., p. 34.
134. Fauseboll, Padakusalamāṇava Jātaka No. 432, p. 508; Cowell, Eng. Trans. p. 302.
135. Eng. Trans., Vol. III, Book XI, 32.1. 1, p. 200.

and Woodward identify it with cumulus), 4-wind clouds (वातवलाहक—perhaps cloud formed due to the activity of convection current in the atmosphere) and 5-rain clouds (वर्षवलाहक—most probably cumulonimbus which brings copious downpour of rain).

The Aṅguttara-Nikāya[136] mentions its own four categories of clouds; 1-producing rumbling but no rainfall (these may be identified with cumulus or thunder clouds), 2-causing rainfall, but no rumbling (generally the description agrees with nimbus), 3-without rumbling and rainfall (the characteristics given most probably signify stratus clouds), and 4-producing rumbling and downpour both (it is illdefined, but can be conjectured to denote the cirrus species—a high altitude cloud).

Thus we see that the Buddhists at least before 400 B.C. (the approximate date of the composition of Aṅguttara Nikāya) have attempted at a very scientific classification of clouds and the four genera mentioned by them and discussed above accurately correspond to the most important four genera enumerated in modern meteorology. So much of subtle observation at such an early date is an achievement of no mean order.

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136. Part II. (P. T. S. London), p. 102.

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CHAPTER VI

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CHAPTER VI

THE GREAT HYDROSPHERE

The Earliest Records

It must be admitted beyond controversy that the Ṛgveda had definite knowledge of oceans and its several routes, ocean navigation and ocean trade as is evinced by I. 25. 7; I. 182. 5-6-7 and I. 56. 2 respectively. Use of "hundred-oared ships"[1] further establishes this assertion. The Ṛgvedic people were acquainted with the wealth of ocean also.[2] Indians had good trade with Babylonia in the third millineum B. C. as has been shown by Dr. A. S. Altekar in his dissertation "Ancient towns and cities in Gujerat and Kathiawar,"[3] and the Ṛgveda is believed to have been composed near about this period (or 3000 B. C.). This further fortifies the validity of the preceding assertions.

The Ṛgvedic Indians were not only expert ocean traders, but they undertook naval expedition also to another island,[4] this must point to their adequate familiarity with sea-faring.

But it cannot be said with certainty how many oceans were known at that time. Verse X. 136. 5 mentions two oceans, namely, the eastern and western, whereas IX. 33. 6 and X. 47. 2 speak of four oceans. In X. 90. 15 there are mentioned seven oceans as explained by Mahīdhara and "adopted by Persians."[5] This mention of seven oceans does not appear to be inconsistent in any way when we look through the vista of later geographic conception of the Hindus.

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1. I. 116. 5.
2. I. 167. 2; IX. 33. 6.
3. p. 34.
4. I. 116. 3-4-5.
5. As translated by Du Perron; cf Wilson's Ṛgveda, Vol. VI. p. 375.

Ocean waves are referred to in IX. 50. 1 and wind is recognised as one of the causes of ocean water movements.[6] IX. 97. 40 faintly alludes to tide and knowledge of influence of lunar attraction on its causation. I. 48. 3 also points to some conception of high tide.

The phenomena of ocean-fire is repeatedly mentioned in the Ṛgveda[7] and also in later Sanskṛta literature, but it cannot be said what geological or oceanographic phenomena it actually implies. At least in the Ṛgveda it does not conclusively indicate the existence of volcanoes under ocean water, inas-much as the book does not appear to have any knowledge of volcanoes except a faint reference.

The Sāmaveda was also acquainted with four oceans and their wealth.[7a] The tome also knew that the earth is encompassed on all sides with water (or ocean).[8] In the Atharvaveda in a certain context the number of oceans is given to be four.[9] At another place the word "समुद्रा:" is used and Sāyaṇa explains it as "सप्तसंख्याका:" (seven in number).[10] The Taittirīya Sanhitā not only possessed the knowledge of ocean, but was also acquainted with the fact that there are land masses across it. "This ocean, the spring of a hundred streams expanded in the middle of the world."[11]

The Sāmaveda several times speaks of swelling of mighty ocean or sea.[12] These are definitely allusions to tides, and

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6. I. 19. 7-8.
7. X. 32. 6; VIII. 91. 4-5.
7a. Stevenson IV. 14. p. 103.
8. Ibid, V. 3. p. 106.
9. Eng. Trans. Whitney XIX. 27. 3.
10. Atharvaveda, edited by S. P. Pandit, Vol. III, p. 141.
11. Eng. Trans. Keith IV. 2. 10. 2. p. 324.
12. Stevenson VI. 7. 11. p. 75 ; (सिन्धोरुच्छ्वासे) and XVI. 18. p. 174.

not to any kind of flooding of oceans, as a class of interpreters is prone to believe. In a line it is clearly asserted that the moon is the cause of tides "सोम.....वर्धा समुद्रमुक्थम्".[13] The Taittirīya[14] also refers to the phenomena of tides. In this reference "समुद्रमभित: पिन्वमानम्" the term अभित: implying either sides signifies the action of tides at the mouth of a river or estuary, because those Indians were acquainted with both the geomorphological patterns. Vājasaneyi-Sanhitā[15] mentions tides "as the gathered flood of ocean."

Perhaps the early Vedic people paid no heed to or did not distinguish currents in the ocean waters, because they are not at all referred to at any place.

But these people were acquainted with some sort of ocean vegetation or plankton which they have called as "समुद्रस्यअबका".[15a]

The Taittirīyasanhitā reveals that ocean trade and maritime activities were continuing and progressing also.[15b]

The Śatapathabrāhmaṇa furnishes more information on oceans and oceans phenomena. In I. 1. 3. 5 it says "For in every direction lies the ocean." Does it show that those Indians knew the Arcatic ocean also ? From I. 6. 3. 11 we learn about the western and eastern oceans. In another passage it is said that "ocean flows round these worlds on every side."[16]

Tides are alluded to in this Brāhmaṇa also. A line says 'around the swelling ocean, for the ocean indeed swells round this earth.'[17] Here also like the above mentioned Vedas, the term पिन्वमा or पिन्वते is used.

13. Chapter 10. Part II. 20 (Uttarārcika)—Text.
14. Keith IV. 2. 8. 1.
15. Griffith. VIII. 28.
15a. Vājasaneyi-sanhitā, 17. 4.
15b. T.S. Keith I. 5. 11. p. 83.
16. Eng. Trans. Eggeling IX. 1. 2. 3.
17. Ibid. VII. 4. 1. 9. vide VI. 4. 1. 8.

The Brāhmaṇa informs us that wind is a cause of motion in the waters of a water-body—".....the way of waters is the wind, for when he blows hither and thither, then the water flows."[18] It is, however, a generalised enunciation of what we have already come across in the Ṛgveda.[19]

This Brāhmaṇa, which is really a mine of cultural data, perhaps for the first time in Indian literature appears to give some conception of ocean currents; "Whence the ocean flows round the world (from the east) southwards."[20] "Hence the ocean flows round these worlds from left to right."[21] Most probably these refer to north-east monsoon drift in the Bay of Bengal and northern Arabian sea.

Perhaps volcano in a sea is vaguely referred to thus "..... for he (Agni-fire) is the sea born child of waters."[22]

In the Aitareya Brāhmaṇa also occurs the information that the earth is encircled by ocean.[23] Ocean and ship are mentioned in VI. 21.

The Maitrāyaṇī Upaniṣad unmistakably speaks of tides in the following lines—

"समुद्रवेलेव दुर्निवार्यमस्य अस्य मृत्योरागमनम्"

".....like the tide of the ocean, the approach of one's death is hard to keep back."[24] This Upaniṣad evinces some conception of ".....the drying up of great ocean."[25]

The Epic Age

By the time of the Rāmāyaṇa, the idea or knowledge of the seven oceans had come to prevail, as they are mentioned in III. 74.25 and III. 75.4. But in the Rāmāyaṇa

18. Ibid. VII. 5. 2. 46.
19. Anterior p. 134.
20. Eggeling VII. 1. 1. 13.
21. Ibid. IX. 1. 2. 3.
22. Ibid. VI. 4. 4. 8.
23. Eng. Tr. Keith VIII. 25.
24. Principal Upaniṣads-Radhakrishnan—IV. 2. p. 809.
25. Ibid. I. 4. p. 797.

the names of all the traditional seven seas do not occur. Milk ocean (perhaps this and other names of seven oceans were mere appellations, and not indicative of any attribute) is mentioned in IV. 37. 25. From Kiṣkindhā it is to the east.[26] After it in the same direction is situated the ocean of fresh or pure water.[27] In several verses[28] we read about the saline ocean (लवणार्णव). To the rest of the seven we have no reference. In VI. 40. 39 we read about the "red sea." But it is to the east of Kiṣkindhā and cannot be identified with the present Red Sea.

There in VI. 128. 50 and VII. 34. 6-33-37 are referred to the four oceans, but it is difficult to identify them. Perhaps these are the three oceans on the frontiers of India enumerated as Western sea,[29] Northern sea,[30] Eastern[31] and Southern sea.[32] IV. 11. 4. also speaks of four oceans.

In IV. 43. 53 is named the northern sea. Some of the writers on ancient Indian geography identify it with the North Arcatic ocean and there appears to be no very positive and strong ground to disbelieve it. Then the whole earth is said to be encompassed by oceans.[33]

Ocean fire (वडवानल) traditionally known from the times of the Ṛgveda is spoken of in IV. 40.48-49. Here and there we find references to the other features of ocean like, island, bays or कच्छ [34]. Ocean deeps and submarine mountain are also mentioned.[35]

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26. IV. 40. 43.
27. IV. 40. 48.
28. I. 1. 72; IV. 58.32; VI. 50. 34-35.
29. VII. 34. 28 and VI. 128. 55.
30. VII. 34. 29 and VI. 128. 56.
31. VII. 34. 31 and VI. 128. 53.
32. VII. 34.10 and VI. 128. 54.
33. I. 39. 14.
34. V. 1. 194.
35. IV. 41. 20.

The Rāmāyaṇa reveals good knowledge of ocean fauna,[36] ocean wealth was also known.[37]

In the Rāmāyaṇa we find mention of ocean tides at least a dozen times.[38] The author of the epic knew that the cause of tides is the moon is proved by "विवर्धमानो वीर्येण समुद्र-पर्वणि"[39] and पर्वसूदीर्णवेगस्य सागरस्येव निस्वनः (Roaring of the heaving ocean during the fullness of the moon).[40] During those days पर्व implied the new and full moon.

Mention of waves is also found aboundingly and IV. 64. 5 and II. 114. 7 clearly show that Vālmīki knew that ocean waves are caused by wind or breeze. In other verse[41] extremely high waves resembling the mountains Mandara and Meru are also alluded to. If it be free from the "Oriental hyperbole", the place can be identified in the present with some accuracy.

V. 3. 3 speaks of ocean breeze or ocean wind. VI. 109.21 reveals a knowledge of marine erosion. In III. 35. 18 we find a reference to the influence of ocean on climate; ocean fishes and fisheries were also known as they formed a food resource of inhabitants of an island and these people were ferocious sea-faring tribes.[42]

In the period of the Rāmāyaṇa India's shipping and maritime activities were quite developed and flourishing. Dr. H. Jacobi adduces argument[43] to prove that the epic had no knowledge of sea voyage. He is of the opinion that in those days only boat and river navigation were known. But his assertion has got no ground at all. Only a few

36. VI. 4. 110-113.
37. I. 3. 8.
38. I. 55. 20; II. 6. 27; V. 1. 10; VII. 29. 12 and so on.
39. I. 55. 20.
40. II. 6. 27.
41. V. I. 70.
42. IV. 40. 28.
43. Eng. Trans. of Das Rāmāyaṇa J.O.I.B. Vol. VII. No 3.

expressions will prove this "महानौखि सागरे"[44] or सामुद्रा: or ocean traders.[45] महानौ clearly implies a sea going ship (a very big boat). It is further corroborated by the following arguments :—

(1) Dr. Bülher has shown that there was maritime intercourse between India and Mesopotamia in the 8th century B. C.[46]

(2) Dr. A. S. Altekar adducing arguments from the Baudhāyāna smṛti (5th century B. C.), Sussondijātaka,[47] and Suppārak Jātaka[48] has convincingly proved that there was sufficient ocean-borne trade of India in both eastern and western directions near about the 8th century B. C.[49]

(3) In the 4th century B. C. Kautilya had very accurate knowledge of naval organisation.

The Rāmāyaṇa mentions Yavanas which implied in the days of the book only Greeks,[50] and the Indians had direct contact with them. This must have been through ocean also, as the historical facts would go to prove it. In this connection we must remember that Alexander returned by an ocean route.[51]

(5) Mention of Yavadvīpa (modern Java) in IV. 40·30-31 of the epic is another definite proof to this.[52]

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44. V. I. 177.
45. II. 82. 8.
46. Introduction to Eng. Trans. of Manusmṛti.
47. Cowell Vol. III, P. 124, Fauseboll 188.
48. Ibid. Vol. IV, No. 463.
49. "Ancient Towns and cities in Gujerat and Kathiawar" P. 34.
50. The Age of Imperial Unity, Edited by R.C. Majumdar, P. 101.
51. For further details of ancient Indian navigation, Cf. "History of Indian Shipping and Maritune Activities" by R. K. Mookerji.
52. Vide the Age of Imperial Unity, P. 652.

(6) India had direct maritime contact with Egypt also in the 2nd century B. C.[53]

(7) Dr. Van Der Slean, Director Royal Anthropological Institute, Holland, has proved that nearly 2000 years ago Indians went to the coast of Africa (Zanzibar) and traded there with glass beads made in Brahmapur (Modern Hapur) (U. P.).

(8) Aśokās rock edict XIII shows that the great monarch had foreign relations with various rulers beyond seas.

In the Mahābhārata the idea of the seven seas appears to have established its roots fully and it actually names them[54] Lavaṇa, Ghṛta, Dadhi, Surā, fresh water and milk. Perhaps the Ikṣu sea is omitted. At some places, the epic gives the number of oceans to be four.[55] By the time of the Mahābhārata (400 B.C. to 400 A.D.) the Indians had much developed ocean navigation. In the Vanaparva we read ".....like a ship to the merchant wishing to cross the ocean."[56] They had gathered considerable knowledge of ocean flora and fauna. Whales (तिमिंगल) large fishes (झष) sharks, tortoises, creatures of various forms by thousands and crocodiles are specifically mentioned.[57] Pearls were fished in the oceans bordering India.[58] The indigenous people, however, knew that pearls were fished in other oceans also.

They were fully acquainted with tides and had come to know that the moon is its cause and the new and full moon days are its special occasions.[59] Like the Maitrāyaṇa upaniṣad[60] and the Buddhists the Mahābhārata has used the term वेला for tides.[61]

53. Ibid p. 619.
54. VI. 11. 6 & 10, and VI. 12. 2.
55. I. 74. 107; II. 9. 18.
56. III. 31. 24.
57. I. 21. 4-5.
58. V. 9 11.
59. I. 2. 11 and V. 151. 56.
60. Anterior p. 136.
61. VII. 159. 73.

The following verse of the Mahābhārata glimpses as if some primitive attempt was made for the bathymetric survey of the ocean.

"The Ṛṣi Atri of great austerity could not fathom its bottom, lower than the nether regions, though he tried to do it for one thousand years."[62]

Here we read at several places about marine volcanoes.[63] They have been designated as पातालज्वलनाभासः. Another verse reads पातालज्वलनशिखाविदीपिताङ्गम (समुद्रम्).....the ocean-lighted with the flames of subterranean fire."[64]

Like the Rāmāyaṇa, this epic also mentions a sea of the name of लौहित्य,[65] but most probably this is not the modern Red sea. In the Ādiprava we read about shores of a salt sea where a grass named "एरका" grew in abundance.[66] Was it Alfalfa or esparto native of Spain or something else ?

Pāṇini :

"Pāṇini refers to navigable.....समुद्र or ocean (IV. 4. 118). He knows of two kinds of islands. viz (1) near the sea-coast (अनुसमुद्र), and (2) in the main ocean. Goods imported from the former were called द्वैप्य, and from the latter द्वैप्य or द्वैपक (IV. 3. 10)."[67]

Baudhāyana Dharmaśāstra: (500 B. C. or earlier)

In this smṛti we have got repeated references to ocean voyages, for example II. 1. 2. 2. Here occurs the actual expression "making voyages by sea" (समुद्रसंयानम्). Govinda, the commentator, explains "समुद्रसंयानम्", 'making voyages by sea,' by 'voyaging by means of ships to another continent

62 I. 21. 13.
63. I. 21. 7 and I. 22. 9.
64. I. 22. 12.
65. I. 2. 364.
66. I. 2. 353.
67. "India as known to Pāṇini," by Dr. V. S. Agrawal, p. 155.

dvīpa.[68] The celebrated law giver also gives rule regarding the duty payable on goods imported by sea.[69]

Manu further testifies to the flourishing state of ocean navigation and trade, "For a long passage the boat hire must be proportional to the places and times; know this (rule refers) to (passages along) the banks of rivers; at sea there is no settled freight."[70]

Arthaśāstra

In the chapter on Nāvādhyakśa in the Adhikarana 2 of the Arthaśāstra Kautilya lets us know that in his time ocean navigation and coastal shipping both were quite satisfactorily developed. In this connection the term समुद्र-संयानम् used in the opening paragraph of the aforesaid chapter must be explained in the same way as we have found just in one of preceding paragraphs interpreted by Govinda in the Baudhāyana Dharmaśāstra to signify navigation to another dvīpa or island. Here it must be remembered that the latter work preceded the Arthaśāstra only by a century or near about that, hence the word समुद्रसंयानम् must have been used in the same sense in both the texts.

Kautilya was fully acquainted with corals and pearls, the places of their occurrence in the oceans flanking India and away from it and their fishing.[71]

Kāmāndakīya Nītisāra refers to tides and their causation thus, "Even as the moon affords delight into the mighty ocean."[72]

The Purāṇas

Almost all the Purāṇas tell us that there are seven oceans in all and name them as लवण, इक्षु, सुरा, घृत, दधि, दुग्ध and

68. Eng. Trans. of the text by Bühler, p. 217.
69. I. 10. 18. 14.
70. Manusmṛti VIII. 406.
71. Chapter XI. p. 86 Eng, Trans., R. Shamasastri.
72. P. 4.

fresh water.[73] Their respective areas (literally extent) are given to be 1, 2, 4, 8, 16, 32 and 64 lakh yojanas.[74] They are described to be concentric circles encompassing the seven traditional continents. But this appears to be all legendary. So far as the above mentioned seven names of oceans are concerned they should not be taken to imply any particular attribute. All the Purāṇas themselves do not specifically say so. लवण, इक्षु and others are mere names just as we have today Black Sea, Dead Sea or Red Sea, whose names have little to do with their waters.

That the true cause of the colour of ocean water is scattering of light is explained a little vaguely in the poetic language thus: "When the sun prevails either in the northern or southern hemi-sphere day or night goes into waters according as they are attacked by darkness or light; it is for this reason that waters appear dark by day because night is within them and white by night because when the sun is set the light of the day enters therein."[75]

The concept of वडवाग्नि or ocean fire was continuing un-interruptedly in the Paurāṇic age.[76]

By the time of the composition of the Purāṇas, tides, their causation, various other aspects and amplitude were carefully and accurately studied by the Indians. This assertion is corroborated by a large number of the Purāṇas.[77] Generally these make the same statement on the topic couched almost in the same words. Hence only one quotation from the Matsya Purāṇa would be sufficient in this context. It says "When the moon rises in the east, the sea begins to swell. The sea becomes less when the moon wanes. When the sea

73. E. G. Viṣṇu Purāṇa Anśa II, chapter II. 6.
74. Ibid, Anśa 2, chapter 4.
75. Ibid VIII. 23-24-25; MND P. 139.
76. The Matsya 121. 77 and others.
77. Viṣṇu, Anśa II, sec. 4, verse 87 to 91; Matsya 123. 30-34, Agni 119. 25-26. Brahmāṇda XIX. 131-36; Brahma XX. 91-94. Vāyu 49. 127-131.

swells, it does so with its own waters (and not with additional waters), and when it subsides, its swelling is lost in its own water (and does not actually lose any water). On the rising of the moon, the sea increases as if its waters have really increased. During the bright and dark fortnight, the sea heaves at the waning of the moon and becomes placid at the wane of it, but the store of the water remains the same. The sea rises and falls, according to the phases of the moon and 510 Aṅgulas (nearly 32 feet) is the measure of its rise and fall on the two Parva days (that is, full moon and new moon respectively)."[78]

It is really much creditable that the Indians several centuries before the beginning of the Christian era or near-about it (as this is the date of the composition of the important Purāṇas) observed and knew so much about tides one of the most important oceanic phenomena. The amplitude of tides given here and in other Purāṇas is also very accurate. Generally on Indian coasts it is nearly 32 feet.

Siddhāntas

In several Siddhāntas there is a topic or chapter designated as भुवनकोश or भूगोलाध्याय which furnishes some information regarding oceans; but it is very general and confined merely to the mention of names of the seven oceans because most of such treatises have derived their material from the Purāṇas as their primary source and appear to have improved nothing in this direction on the latter works.

In this connection it is quite sufficient to cite only two examples: 1—the Siddhāntaśiromaṇi and 2—Vaśiṣṭha Siddhānta (prior to 600 A. D.).[79] In the former work भुवनकोश forms the third chapter and mentions the traditional seven names of the oceans. The latter also comprises a section भूगोलाध्याय. But there is nothing worth-mention.

78. The Matsya 123. 30 to 34.

79. Bhāratīya Jyotiṣa S. B. Diksita (Hindi) p. 238, 244, 245. Vide Bhuvanakośa of the Śiṣyadhīvṛddhida of Lalla and other astronomical works.

Similarly some of the Archaeological treatises also contain a section or chapter or several chapters on भुवनकोश or geography, for example, the Samarāṅgaṇa-sūtradhāra Aparājitapṛcchā and their knowledge also is merely derivative, absolutely devoid of any independent study or painstaking, and hence adds nothing on oceans or oceanography.

In the Yogavāśiṣṭha we come across a description of a Magellan-like ocean navigation. The narrative continues, "Making firm determination to find the end of the earth, those princes set out from their home. They spent long period of their lives in crossing several continents and oceans one after another but could never reach the last point of the earth."[80] This clearly evidences that not only coastal shipping must have been developed, but direct voyages from ocean to ocean were also undertaken as a matter of course.

The Brāhamaṇas were pioneer in sea-faring and navigation in Ancient India. They formed the best sea-captains and expert in ocean navigation (नियमिक-ज्येष्ठ). This statement is unchallengeably established by various narratives of Indian colonial expansions, in which the name of Kauṇḍinya,[81] a Brāhamaṇa, is most conspicuous, who went from India to Combodia in round about the fourth century A. D. and founded a powerful empire.

This is further proved by the Śukranīti. It lays down thus for compulsory foreign travels for Brāhamaṇas. "The earth swallows the king who does not fight, and the Brāhamaṇa who does not go abroad, just as the snake swallows the animals living in the holes."[82]

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80. Nirvāṇa Prakaraṇa, Uttarārdha, Sarga 131. 13 to 15.
81. Vide Indian Cultural Influence in Cambodia by B. R. Chatterji pp. 2, 3, 11, 12, 21, 22. Also inscription of MiSo'n, No. III, BEFEO. IV, 919. Also ancient Indian colonies in the Far East, Suvarṇadvīpa, Vol. 2, Part I and II by Dr. R. C. Majumdar.
82. Śukranīti, IV. 7. 604-5.

Poet Kālidāsa was a great scholar too. During his long travels he had observed oceanic phenomena and their panoramic beauty. He was acquainted with the concept of seven oceans.[83] He knew tides and their causation—महोदधेः पूर इवेन्दु दर्शनात्[84]; and हरस्तुकिञ्चित् परिलुप्तधैर्यश्चन्द्रोदयारंभ इवाम्बुराशिः.[85]

In the canto XIII of the Raghuvaṁśa he gives a vivid description of the ocean, which excels not only in poetic beauty but provides a good deal of scientific information also. The poet refers to submarine mountains,[86] fauna (sharks and large fishes),[87] coral reefs and conches[88] and sandy beach, oysters and pearls.[89]

The Pañcatantra calls a big ocean-trader सांयात्रिक, यथा-समुद्रेऽपि च पोतभङ्गे, सांयात्रिकोवाञ्छति तर्तुमेव."[90] About tides it says, "क्षीणः श्रयति शशीरविमृद्धो वर्द्धयति पाथसानाथम्"[91] (the moon when in full orb swells ocean).

The Kathāsaritsāgara of Somadeva reveals that the ancient Indians undertook oceans voyages frequently.[92] For denoting very big ocean going vessels, text uses the terms यानपात्र,[93] प्रवहण[94] and पोत.[95]

Centuries before Christ the Indians undertook risky voyages and faced all perils of open sea is proved by the following quotation :

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83. Raghuvaṁśa X. 21.
84. Ibid III. 7. and V. 61, XVI. 27.
85. Kumārasambhavam III. 67.
86. Raghuvaṁśa XIII. 7.
87. Ibid XIII. 11.
88. Ibid XIII. 13.
89. Ibid XIII. 17.
90. Mitrabheda 216, also 345.
91. Aparikṣitakārakam, 97.
92. Lambak 3, Taraṅga 4 and 5. 2.
93. 3. 4. 293.
94. 3. 4. 296.
95. V. 3. 116.

"The first Greek reached India from Egypt was Eudoxus. On the first occasion (C. 120 B. C.) he was accompanied by an Indian who had been blown from India to the coast of Africa, while on his return from the second voyage (C. 115 B. C,) Eudoxus himself was driven out of his course on to the Ethiopean shore."[96]

Any survey of the Brāhmaṇic achievements in the field of ocean navigation would remain incomplete, unless it incorporates at least a brief reference to the splendid accomplishments of the Cholas in the mighty main.

During the reign of the Chola dynasty Indian navigation passed through such an epoch which is not to be met frequently in the ancient Indian history. Through the unique efforts and exceptional enthusiasm of Rājarāja the Great (985-1014 A. D.) and his successor the naval hegemony of the Cholas reached its acme.

The Cholas possessed a formidable navy and enjoyed indisputable supremacy not only in the Bay of Bengal and adjoining eastern seas, but also in the west. They exercised unassailable control on the Coromandal and Malabar coasts. They had reduced the Bay of Bengal to a domestic "Chola lake." They had led several naval expeditions against the famous and mighty Shailendra empire and in the multifarious engagements inflicted crushing defeats on them and their vassal states.

Several inscriptions of Rajendra Chola, dated between A. D. 1024 and 1043 furnish a graphic detailed account of his overseas campaigns.[96a]

From this it can be easily inferred that the Cholas must have developed not only navigation in the open sea, but they would have peremptorily advanced the knowledge of oceanography and hydrometeorology also. Further re-

96. "A History of Geographic Discovery and Exploration" by J. L. Baker, p. 19.

96a. Cf. translation of such an inscription in the Struggle for Empire, edited by R. C. Majumdar, p. 731.

searches on the Cholas and their naval organisation and navigation are expected to provide sufficient ancient data and material on the state of the abovementioned two geographic sciences during the period.

Jain Tomes and Chronicles

The Vasudevahiṇdi (C. 500 A. D.) and Samarāiccakahā (8th century A. D.) evince that the Jainas had sufficient knowledge of oceanography and ocean-navigation. But none of their scientific treatises, canonical and non-canonical works and belles lettres show that they achieved something original or independent in this field or made any worthwhile contribution to those sciences otherwise. In this respect perhaps they stand in contrast with their counterparts—the Buddhists.

From the Vṛhatkṣetrasamāsa a work of seventh century, it appears that the Jainas had developed a scientific sense at least to some extent to write on oceanography. This averment is founded on the two chapters of the text designated as लवणाब्ध्यधिकार and कालोदध्यधिकार. In the former Adhikāra are discussed the dimensions of the Lavaṇa ocean, its abysses, tidal actions, various islands in it and its depth and level of water. Similarly the latter details the dimensions of Kalodadhi, nature of its water and other aspects.

In the commentary of the Sūtra 7 of the chapter 3 of the Tattārthādhigama Akalaṅkadeva names eight important oceans : 1—Lavaṇoda, 2—Kaloda, 3—Puṣkaroda, 4—Varuṇoda, 5—Kṣiroda, 6—Ghṛtoda, 7—Ikṣūda and 8—Nandīśwaroda. The Vṛhatkṣetrasamāsa (Tīkā) enumerates nine conspicuous oceans : 1—Lavaṇoda, 2—Kaloda, 3—Puṣkaravaroda, 4—Vāruṇivaroda, 5—Kśiravaroda, 6—Ghṛtavaroda, 7—Ikṣuvaroda, 8—Nandiśwaravaroda and 9--Aruṇavaroda.[97] Even if these eight or nine oceans existed in reality, now it is wellnigh impossible to identify them exactly.

97. Vṛhatkṣetrasamāsa Adhikāra I; vide chapter VII of this dissertation. The ninth is actually the first of another set of eight.

The Tatvārthādhigama Tīkā speaks of the ocean abysses (most probably of Indian Ocean).[98] Further Tīkā on sūtra 32 in the same continuation shows that the Jainas had specific technical terms to devote inner and outer coast and tidal area. These are अन्तरवेला, वाह्यवेला and अग्रोदक respectively. Modern geomorphology also recognises these three divisions in the development of coast profile.[99]

It appears that the Jainas possessed a very fanciful idea about the causation of tides, just as they fantastically believed that there are two suns and two moons. In this matter they are uninfluenced by the Brāhmaṇic concept which knew the reality. The Jainas said that the ocean impelled by the wind expands in the quarters and rises to a height of 4000 Dhanuhs (16000 cubits).[100]

The Jīvajīvābhigama. a precursor work, says that the cause of tides is strong winds (उदारवात) of Mahāpātāla. It gives correct geographic description of tides, only causation is given wrongly.[101]

The Jainas fostered another odd idea that living beings are found only in some oceans, others are devoid of them.[102]

The Āvaśyakasūtra tells us that Indians were much advanced in navigation and maritime commerce and activities in an era nearly 600 B. C.[103] It uses the word णिज्जामक, (implying a sea-captain) much current in that age in other Indian literatures also.

The Samarāiccakahā abounds in thrilling and harrowing tales of sea voyages undertaken by the Indians.[104] A reference reveals that the contemporary Indians voyaged upto

98. Tīkā by Akalaṅkadeva, III. 32.
99. Wooldridge and Morgan, p. 321.
100. Tiloyapaṇṇatti 4.24 40.
101. Velāvṛddhi, Uddesa II, Sūtra 156 and 158.
102. Tiloyapaṇṇatti, 5. 31.
103. 9. 23. 904.
104. Bhava IV, VI, VII.

China, Suvarṇabhūmi[105] and Ratnadīpa[106] in big ships on the tedious track of the main.

Buddhist Sources

During the Buddhist period oceanography and ocean navigation progressed in India by leaps and bounds. The Buddhists were first in the country to introduce any element of scientific study in the field of oceans, apart from being fully well-versed with their commercial importance as great highways of transport and communication.

Aṅguttaranikāya gives the number of oceans to be four.[107] The Sūrpāraka jataka[108] enumerates six १—खुरमाल or खुरमाली २—अग्निमाल or अग्निमाली ३—दधिमाल or दधिमाली ४—कुशमाल or कुशमाली ५—नलमाल or नलमाली and ६—वडवामुख or वलभामुख समुद्र. In the present day their accurate identification is very difficult, nevertheless, khuramāla, Agnimāla and Valabhāmukha are believed to be the Persian Gulf, the Red sea and the Mediterranean sea respectively.

In the Vinayapitaka (C. 400 B. C.) the seed of oceanography is clearly discernible. The text for the first time has tried to discuss or present the subject systematically in some detail. It says,[109] "There are in the great ocean, then eight astonishing and curious qualities, by the constant perception of which the mighty creatures take delight in the great ocean.

"The great ocean gets gradually deeper, slope following on slope, hollow succeeding hollow, and the fall is not precipitously abrupt.....

".....The great ocean remains of the same nature and passes not beyond the shore.

".....though all the streams in the world flow on till they reach the great ocean, and all the waters of the sky

105. Ibid, p. 327.
106. Ibid, p. 447.
107. III. 80. 3 p. 227 (Edited by Cowell).
108. Cowell, No. 463.
109. Eng. Trans. Davids and Oldenberge (S. B. E.) Vol. III, IX. 1. 3. p. 301.

fall into it, yet it does not thereby seem to be more empty or more full.

"the great ocean has only taste, the taste of salt.....

"Again.....the great ocean is full of gems, gems of various kinds.....that is to say, pearl, chank (शंख), rock (शिला), coral, silver, gold, and...the cornelean (मुसारगल्ल).

"The great ocean is the dwelling place of mighty being, among which are these तिमि, तिमिङ्गल, तिमितिमिङ्गल, असुर (fish, shark, octopus, seademons) and Nāgas.

"There are in the great ocean creatures so constituted that they stretch from one to five hundred leagues."

Thus we see that the Vinayapitaka was acquainted with some concept of bathymetric survey, the underwater topography of the ocean floor, continental shelf, some types of abysses, fixity of its water level, its universal salinity, rocks, pearls, corals, and large number of mineral contents together with its fauna (in which whale is also mentioned in the last line of the quotation).

The Divyāvadāna[110] refers to sub-marine mountains. Later we read about fiery erruption of a volcano agitating ocean waters.[111] The Dīghanikāya calls a shelving beach पहम्.[112]

The jātakamālā of Āryasūra (C. 400 A. D.) further corroborates the knowledge of some concept of the Bathymetric survey and ocean floor investigation. It was definitely acquainted with various sorts of terrigenous deposits. The following extract evidences these points, "While crossing the Nalamālin sea and the others, you must draw sand and stones from the bottom of the sea and charge your ship with as much as she can contain.....that sand and gravel being

110. Edited by Cowell and Neil, Avadāna No. XVIII, p. 229.
111. Ibid p. 594 (ज्वालाकलापोच्छुरितोर्मिचक्रम्).
112. Eng. Trans. Davids, Part I, p. 283, Footnote 2.

pronounced to be auspicious will doubtless tend to your profit and gain. And the merchants, being shown the fit places all along by the deities, who did so out of affection and veneration for Supāraga, drew up from thence what they meant to be sand and stones".[113]

Oceanographic studies are again contained in these words, "..... By means of manifold marks, observing the fishes, the colour of the water, the species of the ground, birds, rocks etc., he knew how to ascertain rightly the part of the sea"[114] ".....on its (ocean's) bottom different sorts of ground extend" and there are deep abysses also in it."[114a]

In the Niddeśa[115] (2nd or 3rd century B. C.) there occurs a paragraph which has made guesses about the vertical stretches of ocean water. It divides ocean waters in three horizontal layers and says that movement in the uppermost layer is caused by wind. It also refers to the occurrence of fishes and tortoises in the ocean. It knew that land-locked seas are not so turbulent in movement.

Perhaps Āryasūra distinguished between waves and currents, and has called the latter "सलिल".[116]

Buddhist scriptures have frequently referred to tides, and used the technical term "वेला" for it.[117] Samudra vaṇika Jātaka[118] speaks of tides of seven palm heights. It reveals that it knew that the moon is the cause of tides. The Milindapañho gives imaginary heights of tides "a hundred, two hundred cubits high"[119] it is really anamolous that the

113. Eng. Trans. Speyers, p. 133.
114. Ibid p. 125.
114a. Ibid p. 126.
115. Vol. II, Edited by Pousin & Thomas, p. 353.
116. Speyers, p. 127. Kern p. 89.
117. Jātaka No. 433, Fousebole, p. 518 (वलंवेला समुद्दस्स), Ibid Jātak No. 527, p. 221.
118. Cowell No. 466.
119. Davids, Vol. II, IV. 6. 57.

Buddhists being so well-versed in oceanography and navigation give the amplitude of tides so erroneously whereas the Puraṇas are almost mathematically accurate in this respects.[120]

The Sūrpāraka Jātaka[121] provides information about quite developed stage of sea-faring and maritime activities. Science of marine navigation was treated as a separate branch of knowledge and bore the specific nomenclature "नियमिकशास्त्र". Individuals seeking to enter upon this profession, industriously acquired the knowledge of the science and art of navigation through theoretical and practical training. In this connection the following extract is noteworthy, "So being skilled in the art of taking a ship out and bringing her home, he excercised the profession of one who conducts the merchant by sea to their destination. And as his navigation was very successful, he was named Supāraga."[122]

The Sūrpāraka Jātaka speaks of very large ocean going vessels which accommodated several hundreds of travellers, "Now there were seven hundred souls aboard this ship."[123]

The Niddesa[124] uses a term Samudrākhyāyikā which means individuals well-versed in the science of oceanography. This shows that in the Buddhist period in India, oceanography has come to occupy a very prominent place as to be recognised and dealt with separately.

Use of Compass

Compasses are made of magnet on the principle that it always points to north-south. Indians were acquainted with magnet from a very long antiquity. The Kaṇādasūtra

120. Anterior p. 143-44.
121. Cowell, No. 463.
122. Jātakamālā, Speyers p. 125.
123. Cowell, p. 90.
124. Pousin and Thomas, Vol. II, p. 368, p. 374.

(मण्यभिगमनं सूच्यभिसर्पणमदृष्टकारणम्),[125] the Mahābhārata (अभिद्रवत्ययस्कान्तमयोनिश्चेतनं यथा),[126] Kālidāsa (शम्भोर्यतध्वमाक्रष्टुमयस्कान्तेन लोहवत्),[127] and several other text testify to this assertion. If the Indians, therefore, might have constructed or used some sort of compass before the Christian era nearabout it, it is not to be questioned and dismissed on the very face. Historians believe[128] that the Chinese came to know or use compass in the first and second century B. C. The Encyclopædia Britannica[129] hazards a conjecture that the Chinese possessed some form of magnetic compass in near about 1600 B. C. From this also it does not appear impossible that the Indians at a very early date invented compass independently or came to know through the Chinese with whom they had so close contact from an era several centuries before Christ.

In this connection the Milindapañho gives a little more support. It tells us that Indian ships sailing between India and China used a special instrument which was closely guarded by the vessel captain. "..... As the pilot puts a seal on the steering apparatus, lest one should touch it" (पुन च परं महाराज निय्यामको यन्ते मुद्दिकं देति—मा कोचि यन्तं आमसित्था 'ति).[130]

Radha Kumud Mookerji has cited[131] the suggestion of a European expert regarding an Ajantā painting that it contains a picture of compass, "Again, in No. 1 the figure

125. V. 1. 15.
126. XII. 211. 3.
127. Kumārasambhavam II. 59.
128. A Sketch of Chinese History by Hawks Pott, p. 62, says that compass was invented in Tang period (6th or 7th century A. D.).
129. Vol. 21, p. 609.
130. Eng. Trans. VII. 2. 16.
131. A History of Indian Shipping and Maritime Activities p. 47.

aft appears to be a compass." The eminent historian gives another very interesting extract from the Bombay Gazetteer,[132] "The early Hindu astrologers are said to have used the magnet as they still use the modern compass, in fixing the north and east, in laying foundations and other religious ceremonies. The Hindu compass was an iron fish that floated in a vessel of oil and pointed to the north. The fact of this older Hindu compass seems placed beyond doubt by the Sanskrit work Macchayantra, or fish machine, which Malesworth gives as a name for the mariner's compass."

132. Vol. XIII, Part II, Appendix A.

Development of Geographic Knowledge in Ancient India

CHAPTER VII

General and Regional Geography

Countries known
Exploration
Colonisation-Diplomatic and International relations.
Regional Geography of World and India
Flora
Fauna
Economic and Commercial Geography
Agriculture
Irrigation-canals and the like
Mineral Exploitation
Trade and Industry
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CHAPTER VII

GENERAL AND REGIONAL GEOGRAPHY

The First Epoch

The Ṛgveda verse I. 35.8 gives a glimpse of the regional geography and states that there are eight mountains, three continents....., I. 121.13 speaking of ninety rivers signifies some vast region. In VI. 47.20 we read about a country which was devoid of cows, a geographic and economic criterion of the Ṛgvedic Āryans. The lines VIII. 4.2 name रूम and रूशम countries. Do these indicate the Mediterranean region and Russia ? The later Brahmāṇda Purāṇa also names a country of the Rusas (Russians ?).[1] Besides there are several countries named in the Ṛgveda which are still unidentified.

Of course, the Ṛgvedic hymns mostly refer to the region west of the Gangā, the Punjab, North-West-Frontier Province, Kashmir and Afaghanistan and mouth of the Indus and Gujarat, which clearly implies that they inhabited these lands. But from this it should not be inferred that their geographical knowledge was confined merely to those territories and they did not know any other land. Further it is just possible that there might have been several sects and tribes of the Ṛgveda Āryans who inhabited other regions have been left out for some reason or other or their reference was not necessitated by the composition. This assertion is based on the same line of reasoning that in the Hamlet, the Śākuntalam, the Paradise Lost or the Stories from Tagore all places, rivers and mountains known to the great authors, the contemporary people and scholars are not mentioned and could not be mentioned.

1. Studies in Indian Antiquities by H. C. Raychaudhari, p. 75. note 4.

Reference to palace in VIII. 6.23, three storeyed building in VIII. 40.12 and X. 66.5-7, one-thousand-columned palace in II. 41.5 and acquisition of hundred towns in IV. 30.20, good roads in 1. 116.4 indicate a good sense of urban geography and town-planning. A solitary mantra X. 97.1 exhibits a sense of distributional geography also. Minerology also had come to have a remarkable beginning. Existence of irrigation canals (कुल्या) is corroborated by X. 43.7 and V. 83.8.

The Sāmaveda refers to seven regions of the earth.[2] Verse IX. 13 names countries of रूम, रूशम, श्यावक and कृप[3]. Regarding these Stevenson remarks[4], "These names seem descriptive of the nations bordering on the country of Hindus, perhaps the nations on the Indus to the west, the Tartars to the north, the Tamilians to the south, and the Burmese or Chinese to the east".

The Taittīriya Sanhitā[5] twice mentions seven hills, but it is difficult to identify them severally. The Atharvaveda recognises nine divisions of the earth.[6] In its पृथ्वीसूक्त (xii) it describes quite geographically regionwise flora, fauna, agricultural products, inhabitation, mines, minerals, custom, language and other things.[7]

During the period of these three Vedas means of transport had quite satisfactorily developed. The Atharvaveda alludes to paths for people (जनायन), track for chariot (रथवर्त्म) and roads for carts (अनसपथ)[8]. The Vedic India was connected with foreign nations also through broad international highways. These were perhaps punctuated with mile stones also.[9]

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2. Stevenson xviii. 5.
3. Vide Vājasaneyi Sanhitā 33.82; Atharvaveda xx. 120.2.
4. Eng. Trans. of the Sāmaveda, p. 136, foot note.
5. Keith vi. 2. 4. 3.
6. Whitney and Sāyaṇa x. 7 (or 9). 14.
7. Vide the Envoi of the present disquisition.
8. Xii. I. 47.
9. Vide सार्थवाह by Dr. Motichandra, chapter II, p. 39. and Atharvaveda xiv. 1. 63 and xiv. 2. 6.

So far as geography of India is concerned the later Vedic literature has recognised three main divisions—Brahmavarta or Āryāvarta, Madhyadeśa and Dakshiṇāptha. The Aitreya Brāhmaṇa[10] deals slightly in a better way with the regional geography of India. For the first time it divides the whole country in five geographical regions—1—ध्रुवामध्यमा प्रतिष्ठा दिश् or Madhyadeśa or middle country; 2-प्राचीदिश or the eastern part; 3-दक्षिणदिश or the southern part; 4-प्रतीचीदिश् or the western quarter; and 5-उदीचीदिश् or the northern quarter. But the Dimensions and limits of these divisions cannot be determined accurately on the basis of the text. Here the inhabitants of the regions are also enumerated. From a comparative study it appears that the Atharvaveda[11] anticipated the concept of this sort of regions.

In the Śatapathabrāhmaṇa we find mention of coal (अङ्गार). A paragraph says, "And again, why there is a barren cow for Mitra and Varuṇa. Now where the gods caused the cast seed to spring,—there is that śastra, (litany) called Āgnimāruta. In connection therewith it is explained how the gods caused that seed to spring. From it the coal (अङ्गार) sprang, and from the coal the Āṅgiras, and after that other animals."[12] From the last line it becomes evident that here fossil coal is referred to. Further the Brāhmaṇa was acquainted with the mode of genesis of the mineral and carboniferous age in the great geological past. Exploitation of coal also must not have been a rare practice.

In the Taittirīya Āraṇyaka there is another reference to coal (अङ्गार).[13] In commenting upon the particular paragraph in which the word अङ्गार occurs, Sāyaṇa has quoted several lines[14] from the Kalpa which contain the term. But

10. viii. 14.
11. xix. 17. 1-9.
12. iv. 5. 1. 1; part II p. 387-88 (Eggeling).
13-14. Taittirīya Āraṇyaka, Edited by R. L. Mitra, p. 423, 424 and 425. Vide "अतीतका अभिनवालोक" by the present author, रश्मि १.

in all the references in the Āraṇyaka and kalpa, it is not clear whether they imply mineral coal or man-made coal.

The Rāmāyaṇa

No doubt the four expeditions in the four quarters of the world in connection with the search of Sita described in IV. 40, 41, 42 and 43 are not scientific geographic narrative, nor could they afford to be so and being chapters of a poetic masterpiece, they may contain some inaccurate details; still they exhibit a profound geographic sense, good concept of exploration in response to geographic expediency and fervour, a definite norm of factual knowledge shooting from geographic curiosity, very superior idea of geographic description of the world and a propensity and endeavour to adhere consistently to such facts and figures. And plausibility of all this has further been accounted for in canto 46 of the Book IV.

The direction for the expedition in the east reveals the following geographic knowledge—

(i) Accurate topography and names of countries and rivers.

(ii) Life of the people of the region.

(iii) Tāla trees indicating the frontiers in the extreme eastern end.

(iv) Mention of some unexplored regions, which should prove incentive for exploration to others who hear about it.

(v) Fixing the outermost boundary of the known land to be China (land of silk and silver—the latter still occurs in the south east China).

Instructions for the quest in the south, west and north furnish the following geographic information—

(a) (i) Accurate mention of the southern countries of India and location of Laṅkā.

(ii) Some of unidentified mountains and places.

(iii) Extreme southern tip of the earth—perhaps the southern pole where there is darkness for six months.

(b) (i) Mention of western lands and places of India and Central Asia (वाह्लीक).

(ii) Various unidentified or mythical mountains, perhaps the occurrence of a large number of mountains points to Central Asian Pamir knot and its branches (vide various theories of Aryan migration).

(iii) Reference to unexplored regions.

(c) (i) Mention of northern lands of India, Afghanistan (काम्बोज), Sogdiana (Śakaland) and Greece.

(ii) Mention of waste plains, mountains and rivers.

(iii) Reference to the Aurora Borealis and northern Arctic ocean (cf. in the preceding paragraph). Here information regarding the northernmost tip of Asia appears to be more exact than that furnished about the extreme ends of the other quarters (vide various theories of Aryan migration).

In nutshell in these four cantoes we have sufficient information about regional geography and topography. It is a sort of more compact and systematic भुवनकोश or क्षितिनिवेश description of the Purāṇas. Perhaps there is less legendary in the geography of the Rāmāyaṇa than in the Purāṇas.

The knowledge of Western Asia and Eastern Europe is further corroborated by I. 54. 20 पल्लव (Iran); I. 54. 21-23 Śaka (portion of Iran or Sogdiana or Seistan), यवन (Greece), काम्बोज, and बर्बर; and I. 55. 2-3 यवन, शक, हारीत and किरात, IV. 42 speakes of rivers flowing towards west which are perhaps चक्षु and वक्षु river (Sir and Amu Dariyas).

Traditionally known seven continents of the earth are mentioned in VII. 3.25 (first interpolation), (the Lord of

seven islands)[15] and VII. 1. 56 (second interpolation) seven insular islands.[16] But nowhere the names of the seven continents are mentioned severally.

Whatever may be the divergence of opinion, a close study of the Rāmāyaṇa reveals that it had quite accurate knowledge of the geography of India—from the northernmost part of the Himalayas to modern Ceylon and from present Baluchistan to Assam and its mountains, rivers, plains, deserts, tracts and towns, flora, fauna, and tribes. Pargiter also shares this view.[17]

Similarly in the survey of the four quarters in the context of the search expedition we have good description of flora and fauna and geographic aspects of the world. Although Dr. H. C. Raychaudhuri says[18] that cantoes 40-43 of the Book IV speak only of five regions of India, his view is obviously erroneous as Sugrīva had proceeded to give some detailed account of the world—the world known to him (to the Rāmāyaṇa) which at least embraced large portion of Asia and eastern Europe at least upto Greece. There is no doubt that in the period of the Rāmāyaṇa these portions of the world were known to the Indians.[19] N. C. Das has very capably tried to prove that America was known to the Rāmāyaṇa.[20]

The General theory (lead by Dr. Jacobi) that Laṅkā of the Rāmāyaṇa was situated near about the Vindhyas or

15. M N D, p. 1639.
16. Ibid, p. 1696.
17. J. R. A. S. London 1894, pp. 231-264 (The Geography of Rama's Exile)
18. Epic and Geographic studies in the "Studies in Indian Antiquities."
19. The Age of Imperial Unity, Ed. by R. C. Majumdar, pp. 651, 615, 616 and the preceding chapter of this work.
20. "A note on Ancient Geography of Asia compiled from the Vālmīki Rāmāyaṇa" (1894).

Central India is also untenable as it is indisputably proved by IV. 40-43; III. 47. 29 and III. 55. 19 that Laṅkā is a big island encircled by ocean. IV. 58.20 gives very accurate distance of Laṅkā from the place of sojourn of Sampāti (in the Vindhyas). The distance given here is near about 100 yojanas or 800 miles to the south which is quite correct. And lastly, by the period of Rāmāyaṇa (800 B.C. to 200 B.C.) the Aryans of northern India must have undoubtedly reached the southern tip of the Cape Comorin and must have known Laṅkā. The description of flora and fauna of the region of Laṅkā proves the same fact.[21]

The Aryans were very fond of geographic discoveries and explorations propelled by war motives, caravan journeys, establishment of hermitages, pilgrimages and economic and other incentives. Paraśurāma is known to have performed the circumambulation of the earth (most probably known lands) several times. Jāmbuwan also has performed this feat.[22] The Himalayas were also considerably explored by this time.[23]

The Rāmāyaṇa had good knowledge of economic and commercial geography as it mentions horses of Kāmboja, Vāhlīka;[24] elephants of high breeds from the Indraśirdeśa;[25] woollen and leather goods from the Kekaya country[26]; silk goods and silver in the neighbouring islands of Java[27]; gold mines in the west and so on.[28]

21. Proceedings of the 14th All India Oriental Conference, Vol I. 1949. Address by M. S. Ane, pp. 206-218 ; also the Geography of Rama's Exile by Pargiter J. R. A. S. (London), 1894.
22. IV. 66.32.
23. I. 38.5 and other references.
24. I. 6.22. N. C. Das in his aforesaid work has identified Vanāyu with Arabia.
25. II. 70.23.
26. II. 70. 19.
27. IV. 40. 30.
28. IV. 42. 33.

Irrigational activities were carried on in the days of the Rāmāyaṇa as is indicated by II. 32. 13.

III. 55. 14-15 and VII. 100. 12 bear testimony to some conception of census also.

In the description of Ayodhyā[29] and Laṅkā[30] and other cities we come across much developed sense of urban geography also.

The Rāmāyaṇa further displays that the communication and transport and internal navigation were in a quite developed stage. The fact of internal navigation has already been discussed in the previous chapter. I. 24. 3 and IV. 40.29 further prove it and again ocean trade being fully known[31] unmistakably presupposes river trade and transport. There were five types of roads वीथी (lanes), रथ्या (streets),[32] उपरथ्या (by-street),[33] महापथ[34a] (roads) and राजमार्ग[34] (national highways). Air transport is repeatedly mentioned. Puṣpaka Vimāna (aeroplane) is too well-known.

The Mahābhārata

By the time of the composition of the Mahābhārata the idea of seven continents girdled by seven oceans was firmly established. The Chapters (11 and 12) on geography in the Bhīṣmaparva mention the name of continents Jambu, Kuśa, Śālamalī, Krauñca, Puṣkara, and the like, and those of the oceans of the Lavaṇa, Dadhi, Wine, Milk, Fresh water, and so on. An island of the name of Sudarśana is said to be of circular shape,[35] but it is believed to be the same as Jambu. In a certain context the number of islands of the earth is said

29. I. 5 and 6.
30. VI. 3.
31. II. 82. 8.
32. V. 53. 21.
33. V. 53. 21.
34a. V. 4. 4.
34. V. 4. 14.
35. VI. 5. 13.

to be thirteen.[36] In VI. VI. 7-9-10 we read the names of the varṣa parvatas like Hīmavat, Hemakūta, Niṣadha, Nīla, Śveta together with those of Mālyavān and Gandhamādana. Those people were also acquainted with seven Kulaparvatas named Mahendra, Malaya, Sahya, Śuktimān, Gandhamādana, Vindhya and Pāriyātra.[37] The epic knew about other mountains also in addition to these.[38] There is a long list of rivers, most of which belong to India.[39] At one place there is found the enumeration of a large number of countries.[40]

China,[41] Vāhlīka[42] (Balkh), Romaka[43] (Rome), Pahlava[44] (Iran) and Yavana[45] (Greece) are very clearly mentioned. It, therefore, shows that the Mahābhārta knew well about atleast Eastern Europe, eastern coast of Africa, southern parts of Siberia and south east Asia. Besides, the concurrent study of the contemporary texts evinces that by the time of the composition of the Mahābhārata (400 B. C. to 400 A. D.) Indians had come to know the six continents of the modern times.

Jambudwīpa has been divided into nine varṣas—Bhārata, Haimavata, Harivarṣa, Ilāvṛta, Śveta, Hairaṇyaka, Bhadrāśva, Ketumāla, and Airāvata or Kuru.[46] A chapter of the Sabhāparva[47] and other references[48] show that people knew full well the geography of whole India stretching from

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36. III. 3. 52.
37. VI. 9. 11.
38. II. 10. 31-32
39. VI. 9. 13-31-32-36.
40. VI. 9.
41. II. 26. 9.
42. II. 27. 22.
43. II. 51-31.
44. II. 52. 15.
45. I. 177. 35.
46. VI. 6.
47. II. 10.
48. VI. 9.

the Himalayas to the Cape Comorin and from Afghanistan to Assam.

Some of the chapters of the Bhīṣmaparva give a good account of topography, inhabitants, various crops, means of livelihood, multifarious tribes, their political and legal institutions.[49]

The epic shows that travelling was religiously encouraged in India from great antiquity, "He who travels over the earth according to these rules obtains the great fruit of one hundred sacrifices, and finally obtains salvation."[50] Several tīrthas (pilgrim centres) situated on the tops of mountains and other inaccessible places are described in some detail. Information is furnished about pilgrim centres in the four quarters,[51] crossing of the Himalayas is mentioned several times. All this goes to point that those people were much interested in exploring lands and countries.[52]

Various accounts of the Mahābhārata, specially the Sabhāparva, reveal good knowledge of economic and commercial geography. The 51st chapter of this Parva evinces praiseworthy knowledge of export and import of a large number of commodities. During this period India had flourishing trade with central Asia, countries flanking the Mediterranean sea in the west and East Indies in the east.[53]

The Śānti Parva alludes to seventeen types of crops.[54] Cultivation and manufacture of silk was also in a prosperous state. This is evidenced by the line कृमि हिं कोषकारस्तु वध्यते स परिग्रहात्.[55] The Vanaparva has a brief description of the deciduous forests.[56]

49. VI. 11-12.
50. III. 85. 15. (MND p. 141).
51. III. 87-88-89-90.
52. I. 119. 47 ; III. 85. 115 ; III. 87-88-89-90.
53. II. 51-52.
54. XII. 59. 124.
55. XII. 330. 29.
56. III. 64. 1-4.

This epoch has seen adequate development of roads, specially highways. These linked the Uttarāpatha and the Dakśiṇāpatha. These roads were constructed cutting the mountains[57] एते गच्छन्ति बहवः पन्थानो दक्षिणापथम् । अवन्तीमृक्षवन्तञ्च समतिक्रम्यपर्वतम्. There were numerous international highways also.[58] Internal navigation was progressing satisfactorily.

It is noteworthy that the real beginning of Geopolitics or political geography in ancient India traces its history from the establishment of Gaṇas (democratic states). In the later period Kautilya was the first and foremost authority who wrote quite systematically and succinctly on the subject. In the Mahābhārata we come across commendable concept and knowledge of political geography, international affairs, diplomatic relations and military science. Interaction of forces of political geography and their consequences can be unmistakably read in the great conflagration of the Mahābhārata.

In the Manusmṛti we read about these important nations—Pauṇḍraka, Kāmboja (parts of Afghanistan, may denote the Indian colony of south east Asia, as by about 200 B. C. the Indians had developed this part), Yavana (Greek), Śaka, Pahlava (Iran), China, Kirāta, Darada and Khaśa.[59]

Like modern treatises on geopolitics, Manu has attempted to classify frontiers in five categories :

ध्वजिनी मत्सिनी चैव निधानी भयवर्जिता ।
राजशाससनीता च सीमा पञ्च विधा स्मृता ॥[60]

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57. III. 61. 21.
58. III. 177. 12 (MND p. 257).
59. X. 44. For identification and further details cf—The Ancient Geography of India by A. Cunningham ; Geographical Dictionary of Ancient and Mediæval India by N. L. Dey ; Studies in Indian Antiquities by Dr. H. C. Raychoudhari.
60. Kulluka says that this verse is an interpolation No. 19 after viii. 265.

ध्वजिनी appears to be a frontier marked by mountains, मत्सिनी perhaps embraces a water boundary, the निधानी may be artificially demarcated, a frontier indicated by ocean, big rivers and lakes is probably defined as भयवर्जिता, and that are marked by a ruler's rock-edicts may be known as राजशासननीता ।

Though in the six system of Indian philosophy we should expect nothing of regional geography, still in the Pātañjali's Yogasūtra (near about the beginning of Christian era) there occurs an aphorism[61] which gives or contains a good deal of regional geographic information in the seed form. In the Vyāsa Bhāṣya it has been developed to a considerable extent.

The Bhāṣya mentions seven continents—Jambu, Śaka, Kuśa, Kruñca, Sālmala, Magadha and Puṣkara as also the seven oceans of Lavaṇa, Ikṣu, Surā, Ghṛta, Dadhi, Dugdha, and Water. Here a continent is differently named from the tradition of the Purāṇas. Instead of traditional Plakṣa we have got Magadha.

Jambudvīpa is said to be comprised of seven varṣas—रमणक, हिरण्मय, उत्तरकुरु, हरिवर्ष, किम्पुरुषवर्ष, भारत and इलावृत and seven mountains निषध, हेमकूट, हिम, भद्राश्व, माल्यवान्, केतुमाल and गन्धमादन. These two lists also vary from the Pauraṇic tradition. These names and geographic facts would be discussed in detail under the subsequent caption "The Puraṇic Development." It should however, be remarked that in the realm of regional or general geography, the Vyāsa Bhāṣya adds nothing particular.

Pāṇini

A general study of the Aṣṭādhyāyī reveals that Pāṇini was acquainted with some concept of the term "Bhuvana-kośa.[62] The Grammarian gives a list of names of mountains.

He knew about the systematic cultivation of forests.[63] He gives the classification of forests on the basis of its

61. III. 26 and its Vyāsa Bhāṣya.
62. India as known to Pāṇini—Dr. V. S. Agrawala, p. 39.
63. Ibid 210.

produce—ओषधिवन, producing herbs, and वनस्पतिवन producing timber.[64]

Pāṇini was acquainted with the river navigation in the country, as he speaks of navigable rivers like the Sindhu.

From the Pāṇinian grammar, valuable information can be collected on mines and mining operations. The following quotation[65] would justify this assertion. "The miner (खनक) is referred to by Kātyāyana on III. 1. 145. Mining revenue was called आकरिक (cf काशिका on IV. 3. 75). Pāṇini refers to seams as प्रस्तार (III. 3. 32), on which the काशिका cites मणिप्रस्तार, the veins of gems. The same word occurs as प्रस्तर in Kautilya. Traders dealing and the प्रस्तार minerals were called प्रस्तारिक (IV. 4. 72)"

Pāṇini knew about various kinds of routes, such as वारिपथ (water route), स्थलपथ (land routes) रथपथ (chariot-roads), करिपथ (elephant roads), अजपथ (goat streets), शङ्कुपथ, राजपथ (Highways) and सिंहपथ. Two air-routes are also referred to. They are हंसपथ and देवपथ.[66]

In Pāṇini's time there existed a large number of trunk roads which linked the various parts of the country as well as different foreign lands.[67]

He mentions four patterns of population settlement 1—नगर (Town), 2—ग्राम (village), 3—घोष ghoṣa (abode of herdsmen) and 4—खेट (hamlets). Further Dr. Agrawala has shown that in the time of Pāṇini good concept of urban geography prevailed in the country.[68]

Versatile Kautilya and his Successors

In modern economic and commercial geography the topics generally dealt with are agriculture, irrigation, cattle-

64. Ibid 210.
65. Ibid, p. 231.
66. V. 3. 100.
67. India as Known to Pāṇini, p. 244.
68. Ibid, p. 137.

rearing, various mineral resources, industries and commerce, transport and communication, population and census of men and animals. The general notion, however, is that ancient Indians had no sense or concept of economic and commercial geography and they were totally ignorant of the methodology of these two branches of knowledge. But this view is totally erroneous.

The Arthaśāstra of Kautilya possessed a profound sense and epistemology of the above branches of geography, and not only this, but its dialectics and methodology of the treatment of the above mentioned subjects also are much in conformity with the established modern principles and methodology of presentation. The following chapters[69] of the Arthaśāstra amply justify this affirmation (a) Superintendent of Agriculture, (chapter xxiv. p. 142 on agricultural activities, its environment and irrigation), (b) The Superintendent of forest produce (chapter xvii p. 121 and chapter xi p. 363 on forests and their resources); (c) The Superintendent of cows (chapter xxix, p. 159 on cattle rearing); (d) The Superintendent of mines and Superintendent of Treasury (chapter xii, p. 94 and xi p. 86—on mining operation and manufacture, and examination of gems, mode of occurrence and exploitation of mineral wealth on land and sea and industries connected with it); (e) The Superintendent of commerce (chapter xvi, p. 118 on commercial activities) ; (f) Chapter xi, p. 363 and xii, p. 366 on transport and communication (trade routes) and, (g) chapter xxxv p. 178, population and census of men and animals, land utilization and emigration and immigration.

Since it would make this dissertation unmanageably bulky, here it is sufficient to cast a searching glance only on the aforesaid chapters to examine them through the scientific kaleidoscope of geography proper.

In chapter xxiv on the Superintendent of Agriculture adequate light is thrown on interrelationship of rain, wind

69. Here the numbers of chapters are according to R. Shamasastri. The whole work is divided in 15 books.

and sunshine and cultivation of crops like rice, wheat, pulses, oil seeds, sugarcane and vegetable.[70] The seasons of sowing of these crops are also mentioned.

The crops are classified into three categories—wet crops (केदार), winter crops (हैमन्त) or summer crops (ग्रैष्मिक), as is done now-a-days in India.[71]

Four types[72] of irrigation is spoken of—(i) by manual labour (हस्तप्रावर्तितम्), (ii) by carrying waters on shoulders (स्कन्धप्रावर्तितम्), (iii) by water lifts (स्रोतोयंत्रप्रावर्तितम्—water supplied by channels—cannals—कुल्या commentary); and IV —by raising water from rivers, lakes, tanks and well (नदीसरस्तटाककूपोद्घाटम्).

Chapter XI (p. 363) and XVII (p. 121) furnish almost all the modern types of geographic information on forests. The former recognises two classes of forests—(i) timber forests and (ii) elephant forests.[73]

The chapter XVII[74] really extorts our unreserved admiration in being one of the profoundest piece of methodology of scientific geography. Under the head—the trees of strong timber (सारदारुवर्ग) a large number of varieties of trees is mentioned accurately ; the bamboo group includes another list ; so is the case with the class of creepers ; fibrous plants form another group ; rope-making materials are put under a separate head ; leaf-plants include a large species ; then several flowers are put in another class ; and medicines and poisons form two other different groups. Skins, bones, and cattle are the fauna resources of forests. Metals, pottery materials and various fuels like charcoal (most probably fossil coal inclusive) are also specifically mentioned. Beasts,

70. Ibid, p. 143-144.
71. Ibid, p. 144.
72. Arthaśāstra ; number of chapters are according to R. Shamasastri, p. 144.
73. Ibid p. 363.
74. Ibid pp. 121 to 123.

cattle and birds are said to be the sources for menageries. Firewood and fodder are the other two forest wealth.

The chapter XXIX[75] deals with the rearing of milch animals, sheep, goat, horses, asses, camels, hogs and the like. Dairing and dairy products are discussed in some detail.

Mode of occurrence, characteristics, distribution and method of mining of gems is explained in chapter XI.[76] It further discusses the manufacture of woollen goods, blankets, silk goods, cotton fabrics and production of other raw and finished commodities.

From the following chapter[77] we gather information about prospecting, occurrence and exploitation of minerals. It tells us that ore may be found on plains as well as on mountains—occurrence of ores of gold, copper, silver, iron, lead, tin and others is quite scientifically detailed. It is also stated that some minerals are found in impure, mixed or compound state. Refining of minerals is also referred to. Two paragraphs make brief allusions to the manufacture of various commodities from the metals and minerals.

In the chapter XVI[78] are discussed internal movement of commodities, foreign imports and exports, transport of merchandise and relevant features of commercial towns.

In the chapter XII[79] talking of trade routes, the Arthaśāstra says, "This explains the selection of trade of routes :

"My teacher says that of the two trade routes, one by water and another by land, the former is better, in as much as it is less expensive, but productive of large profits.

"Not so, says Kautilya, for water route is liable to obstruction, not permanent, a source of imminent dangers,

75. Ibid p. 169.
76. Ibid p. 86.
77. Arthaśāstra ; number of chapters are according to R. Shamasastri, p. 94.
78. Ibid p. 118.
79. Ibid p. 367.

incapable of defence, whereas a land route is of reverse nature.

"Of water routes, one along the shore and another in mid-ocean, the route along and close to shore is better, as it touches at many trading port-towns ; like-wise river-navigation is better, as it is uninterrupted and is of avoidable or endurable dangers.

"My teacher says that of land routes, that which leads to the Himalayas is better than that which leads to the south.

"Not so, says Kautilya, for with the exception of blankets, skins, and horses, other articles of merchandise, such as, conch shells, diamonds, precious stones, pearls and gold are available in plenty in the south.

"Of routes leading to the south, either that trade route which traverses large number of mines, which is frequented by people, and which is less expensive or troublesome, or that route by taking which plenty of merchandise of various kinds can be obtained is better.

"This explains the selection of trade routes leading either to the east or to the west.

"Of a cart tract and a foot-path, a cart-track is better as it affords facilities for preparations on a large scale.

"Routes that can be traversed by asses or camels, irrespective of countries and seasons are good.

"This explains the selection of trade routes traversed by men alone (अंस पथ), shoulder path i. e., a path traversed by men carrying merchandise on their shoulders."

The chapter xxxv reveals that the method of taking census was almost the same as in modern times. Informations were collected almost on all those topics regarding census which are deemed relevant and important now-a-days.

If we search for practical philosophy of the economic geography and geopolitics, Kautilya provides some of most sanguine principles. The standard of his theorisation and discussion very well compares with that of Ratzel, Herfort Makinder and other scholars of political geography of

modern times. A brief quotation[80] would amply prove the validity of this statements—

"The agreement made under the condition, 'Let us colonise wasteland' is termed an interminable agreement.

"Whoever of the two parties of the agreement colonises a fertile land, reaping the harvest earlier, overreaches the other.

"Which is better for colonisation : a plain or watery land ?

"A limited tract of land with water is far better than a vast plain, in as much as the former is conducive to the growth of crops and fruits throughout the year.

"Of plains, that which is conducive to the growth of both early and late crops and which requires less labour and less rain for cultivation is better than the other of the reverse character.

"Of watery lands, that which is conducive to the growth of grains, and another, vast and productive of crops other than grains, the latter is better inasmuch as it affords vast area not only to grow spices and other medicinal crops, but also to construct forts and other defensive works in plenty : for fertility and other qualities of land are artificial.

"Of the two tracts of land, one such in grains and another in mines, the latter helps the treasury, while the former can fill both treasury and the store house ; and besides this, the construction of forts and other buildings require grains. Still that kind of land containing mines and which yields precious metals to purchase tracts of land is better.

"My teacher says that of the two forests, one productive of timber and another of elephants, the former is the source of all kinds of works and is of immense help in forming a store house, while the latter is of reverse character.

"Not so says Kautilya for it is possible to plant any number of timber forests in many places, but not an elephant forest ; yet it is on elephants that destruction of an enemy's army depends.

80. Chapter XI, pp 362-64, as numbered by R. Shamasastri.

"Of the two, communication by water and by land, the former is not long-standing, while the latter can ever be enjoyed.

"Which is better, the land with scattered people or that with a concentration of people ?

"The former is better inasmuch as it can be kept under control and is not susceptible to the intrigues of enemies, while the latter is intolerant of calamities and susceptible of anger and other passions.

"In colonising a land with four castes, colonisation with the lowest caste is better inasmuch as it is serviceable in various ways, plentiful and permanent.

"Of cultivated and uncultivated tracts, the uncultivated tract may be suitable for various kinds of agricultural operation and when it is fertile, can be adapted for pasture grounds, manufacture of merchandise, mercantile transactions of borrowing and lending, and being attractive to rich merchants, is far better than a cultivated tract.

"Which is better of the two, the tract of land with forts or that which is thickly populated ?

"The latter is better : for that which is thickly populated is a kingdom in all its senses What can a depopulated country like a barren cow be productive of ?"

From the above it is clear that Kautilya has very capably and logically examined the pros and cons of colonisation also, which was much in vogue in ancient India. Kalidasa also has referred to this point.

Territorial aggrandisement—expansion, its geopolitical implication, power politics and international consequences are also succinctly touched upon in this chapter.[81]

Unfortunately the later similar treatises Kāmāndakī-Nīti-Sāra and Śukra Nītisāra[82] could not at all improve upon

81. Accordingly as by R. Shamasastri, p. 365.

82. In his "Positive Background to Hindu Sociology," B. K. Sarkar says, about the Śukranīti. "It may be

Kautilya, the prodigious geopolitic and geographic genius of ancient India.

The Paurāṇic Development

In all the Purāṇas there occurs a particular topic designated as भुवनकोश, in which are actually discussed the general and regional geography of the world and India both. Every Purāṇa has devoted several chapters to the भुवनकोश. These chapters, however, contain a lot of fabulous or legendary material. In the realm of world geography this element has not only always played a dominant role, but not infrequently ousted the real scientific geographer. So far as geography of India is concerned we have generally scientific details which are presented also systematically and satisfactorily.

As a rule the Purāṇas have conceived the earth to be comprised of seven continents.[83] Only the Padma Purāṇa has increased that number to nine.[84] The seven continents are concentric and circular and every two of the continents is separated by a sea and every continent is in area double that of one that is interior to it,[85] since the innermost continent Jambu is one lakh yojanas in area,[86] the others are 2, 4, 8, 16, 32 and 64 lakh (square) yojanas in area respectively. In this very order the names of seven continents

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remarked here that the distribution of the mines, metals, stones and gems mentioned in the Śukranīti covers practically a chapter of the whole economic geology of ancient and mediaeval India." p. 77.

83. Mārkaṇḍeya 53. 17—19 ; Viṣṇu Anśa II, I. 12—15 ; and II. 2. 5, Brahmāṇda (Pūrvabhāga), chapter XIV. 11—14.
84. Padma, Swarga VII. 26 (Quoted in Dr. H. C. Roychaudhary's "Studies in Indian Antiquities," p. 65).
85. Bhāgavata V. I. 31-32 ; Viśṇu II. 2. 6 ; Mārkaṇḍeya 54. 7.
86. Viśṇu II. 3. 27.

are जम्बू, प्लक्ष, शाल्मली, कुश, क्रौञ्च, शाक or शक, and पुष्कर.[87] In some of the Purāṇas the names of one or two continents are given differently, for example, the Matsya calls प्लक्ष as गोमेद्[88] and Brahma Vaivarta names शाल्मली as न्यग्रोध.[89] The latter Purāṇa has changed much the conventional order of the continents also. For our survey, however, it is immaterial as we shall always take into account the usual order mentioned above to which most of the oldest and most authentic Purāṇas have invariably adhered.

Modern scholarship usually treats these continents as merely mythological, inasmuch as from their descriptions furnished in the Purāṇas, it is generally thought to be well-nigh impossible to identify them accurately in the systems of modern geography.

Colonel F. Wilford has tried to throw some light on this point, which is not only interesting, but at the same time appears to have considerable logical appeal also.

He says,[90] "If we disregard entirely the diagrams or fanciful schemes of astronomers, and adhere to the test of Purāṇas, we shall immediately perceive, that these seven zones (cf. fig. 4, 5, 6.) *that is what is conveyed by seven continents* (Italics mine)—are really our seven climates, for Jambu or India is the first, and Puṣkara is declared to be at the furthest extremities of the west, and in the same climate with Uttar Kuru; which last is expressedly said to be country lying south of the northern ocean. Puṣkara is the Thule of Ptolemy, and the modern Iceland, under the Arctic circle, and at least the sensible. It is true that the seven climates in general were not supposed to extend much beyond the Mouth of the Borysthenes, but Ptolemy, and Agathemerus

87. Viṣṇu II. 2. 5 and other Purāṇas.
88. 123 1.
89. Brahma Khaṇḍa VII. 7.
90. "An essay on Sacred Isles in the west, with essays"... Asiatic Researches, VIII, (1805), p. 285.

by dividing each climate into three parts, (like the Hindus who divide the seven zone-like regions of Heaven, hell and earth into three, beginning, middle and the end) thus made twentyone subordinate climates extending from the equator to the polar circle. Every climate was denominated from some famous city, country or island in it, thus we have, the zone or climate of Meroe, that of Rhodes, etc. The dvīpas or the climates of the Hindus, gradually increase in breadth from the equator to the polar circle, from a whimsical notion that they are all equal, as to the superficial continents. The seven zones of the Hindus correspond with the following countries : Jambu as India, Cuśa answers to the countries between the Persian gulf, the Caspian sea and the western boundary of India. Placsha (प्लक्ष) includes the lesser Asia, Armenia, etc. Sālmalī is bounded to the west by the Cronian-sea ; that is to say, the Adriatic and Baltic seas. Craunch (क्रौञ्च) includes Germany ; Śakam (शकम्) the British Isles ; and Puṣkar (पुष्कर) is Iceland."

Here Wilford purports to say two things (i) the seven continents connote and denote climatic regions, and (ii) they denote specific geographic areas which can be identified with lands and countries bearing modern names. Now the nature of interpretation and analysis involved in the above lines is such that both these conclusions may be taken at least to be two guiding principles in the study of Paurāṇic world geography, which has deservedly suffered so much denunciations at the hands of recondite scholars, provided consummate precision is not searched for fastidiously in the pristine details. The logic of Wilford emphasising the two points indicates that they are not merely working hypotheses, but something more than that in the long perspective of antiquity and concurrent data culled from other sources of history, and can never be dismissed lightly and summarily, even if better new hypotheses are promulgated. And new hypotheses must seek some sort of reconciliation with the above two.

This line of reasoning and contemplation is bolstered by later investigations and argumentation by Dr. H. C. Raychaudhuri. Of course, minor divergences of subtle details are discernible in the latter scholar.

He observes,[91] "It is, however, well to remember that the word द्वीप originally meant nothing more than a land between two sheets of water[92] (usually rivers), and that some of the Paurāṇic dvīpas are obviously named after tribes, or connected with localities, which can be identified with more or less certainty. Śakadvīpa, for example, is obviously named after the Śakas and the description of its inhabitants as, "Maga-dvijas" who worship सूर्यरूपधरोहरि clearly points to its identification with Śakasthāna or Seistan the land of Māgi and Mīhīr cults. Votaries of this cult migrated to India in large numbers probably in the Scythian period and constitute the Śākadvīpa community of the present day. The name of the dwīpa mentioned in the Matsya Purāṇa, viz. Kuśa reminds us of the famous race which, according to Kumara Lāta and Baron A. Von Staël Holstein, gave India the powerful emperors of Kaniṣka's line. Plakṣa which is placed next to Jambudvīpa by many Purāṇas as well as the commentator of Pātañjali, has as one of its streams, the river Kramu or Krumu mentioned as early as the Ṛgveda, and identified by scholars with the modern Kurram, a western tributary of the Indus. In one of the Paurāṇic list, we find Kubhā (the Kabul river) in place of Krumu. These facts point to some region immediately to the west of the Indus as the possible site of the Plakṣa dvīpa of the Purāṇas. A Paurāṇic passage quoted by Alberuni places Puṣkar between China and Mangala (Mongolia). Thus the account of the "seven Dvīpas" may have had

91. Studies in Indian Antiquities, pp. 68-70.

92. द्विरापत्वात् स्मृतो द्वीपाः (ब्रह्माण्ड 53.140) cf महाभाष्य, Keilhorn's vol I, p. 131, cf also Śākaladvīpa mentioned in the Mahābhārata (II. 26. 5-6) which was clearly a tract between two rivers (the Rāvi and Chinab).

originally a substratum of reality. But the extant text bearing on the subject are so hopelessly corrupt that the kernel of truth is in most cases buried beyond reach underneath a vast mass of Utopian myths. It is only in the account of Jambudvīpa that the poet has not altogether thrust out the geographer."

It is evident that Dr. H. C. Raychaudhuri has followed the second line of speculation and discussion initiated by Col. Wilford, no doubt the former has endeavoured to adduce more arguments in favour of his assertions.

Jambudvīpa—bearing another appellation "Sudarśana dvīpa"[93] is said to be named "after a tree growing in it...[94]" Its shape is described to be that of a lotus having Meru as its कर्णिका (pericarp) and the varṣas or the big divisions (sometimes known as mahadvīpas) भद्राश्व, भारत, केतुमाल and उत्तरकुरु form its four petals.[95] But the total number of varṣas in the Jambudvīpa is given to be nine[96]—1–भारत, 2–किम्पुरुष, (or किंनर), 3–हरिवर्ष, 4–इलावृत, 5—रम्यक (रमणक)[97],

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93. Cf. Mahābhārata VI. 5. 13.
सुदर्शनो नाम महान् जम्बूवृक्षः सनातनः ।
तस्य नाम्ना समाख्यातो जम्बूद्वीपो वनस्पतेः ।।—Matsa 114. 74. 15.

94. Viṣṇu II, 2. 20 ; Brahmāṇda 37. 28-34 ; & 50. 25-26 (Raychaudhuri. p. 71).

95 Mārkaṇdeya 55.20 ; पृथ्वीपद्मम् मेरुपर्वत कर्णिकम्—Brahmāṇda 35.41 (cf H. C. Raychaudhuri). महाद्वीपास्तु विख्याताश्चत्वारः पत्र संस्थिताः । पद्मकर्णिक संस्थानो मेरु नामा महाबलाः ।। Brahmāṇda 35.50 (Raychaudhuri) ; चतुर्महाद्वीपवतीसेयमूर्वी प्रकीर्तिता, Brahmāṇda 44.35.

96. The Matsya mentions the first seven, 113.21 or 26 ; Mārkaṇdeya names the nine 53. 34-35 ; so also the Bhāgavata V. 2-19 ; But in the latter this भारत is spoken of as Nābhi.

97. Matsya 113. 61.

Maps No. 3 and 4 (Asiatic Researches, Vol. 8. P. 367)
(Wilford's own words).

No. 3. "represents the same, projected upon the plane of a meridian. These two projections are against the tenor of the contexts of the Puranas : a southern hemisphere being then absolutely unknown.

"Here I have placed the three ranges of mountains according to the documents of Hindu astronomers, but not according to their usual delineations, for according to these, the three ranges should be represented by three concentric half-circles, parallel to the meridians of the projection. It is acknowledged that these ranges are in the direction of as many parallels of latitude. In that case the outermost ranges must be the longest: and this is the opinion of the Jainas, as I observed before, in the sixth paragraph of the first chapter of "An Essay on sacred isles in the West" in the Asiatic Researches, Vol. VIII."

No. 4. "exhibits the old continent, projected upon an imaginary circle passing through the north pole, and just grazing the equator in the south. Instead of a circle, it should be an oval, with the longest diameter East and West. But as the tracing of an oval would be attended with some difficulty, the indolent Pauraniks have adopted the circle in its room ; and seldom use the other. As such a delineation would be useless, I have, of course, omitted it.

"The chasm in the north-west, through the mountains surrounding the world, was made by Krishna, when he went to see his prototype Vishnu, ...whose abode is among waters, in the land of darkness. Several heroes passed since through this chasm."

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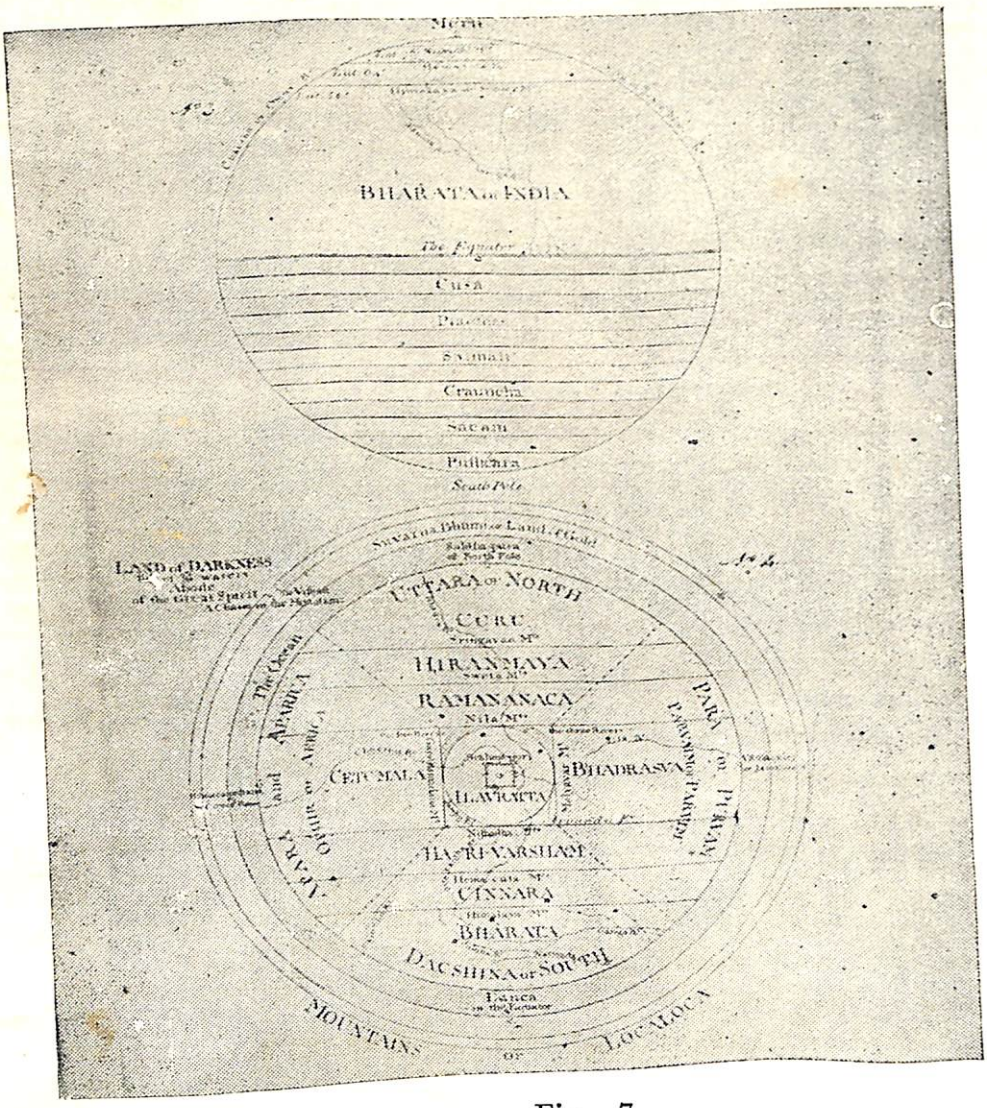


Fig. 7

Wilford's Bhārata and Jambūdvīpa.

(Asiatic Researches Vol.8, P. 367) [P.T.O.]

Maps No. 5 and 6 Asiatic Researches, Vol. 8, P. 367
(Wilford's own words).

No. 5. "explains the true system of the known world, according to the Purāṇas and the Jainas, reconciled with that of the astronomers of India.

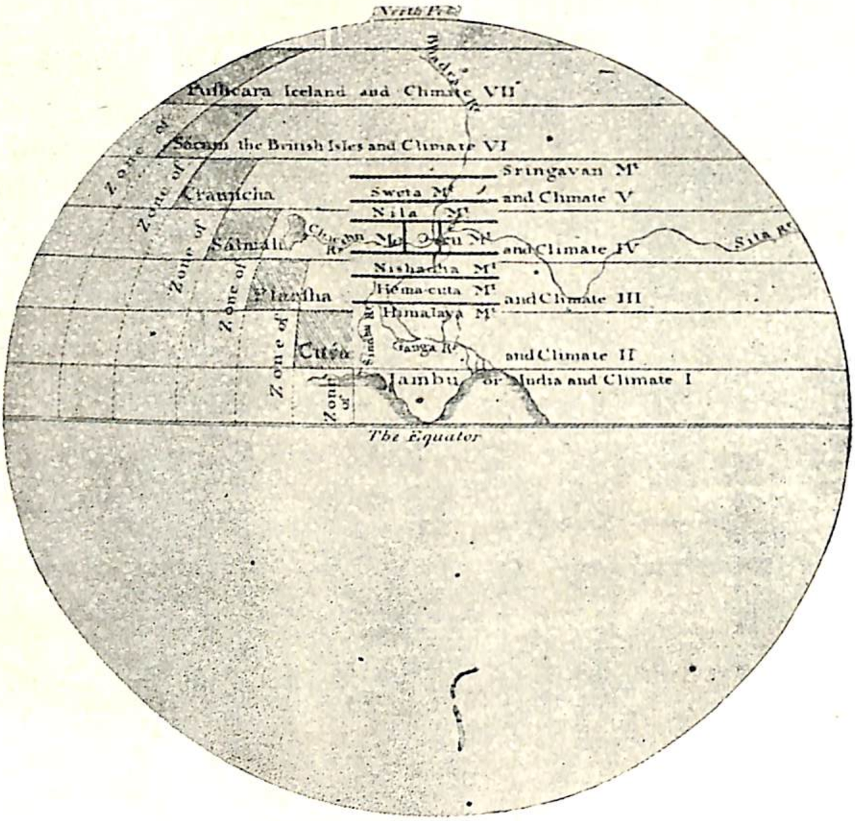
"Here the Meru of the Pauraniks is brought back to its proper place, whilst the Meru of the astronomers remains under the North Pole. The zones between Jambu or India, and the Meru of the astronomers, are obviously our seven climates ; and the points where the astronomical zones intersect the zones of Pauraniks round their respective centres equally called Meru, shew true situation of the dvipas or countries, from which these zones, according to the system either of astronomers or of the Pauraniks, are equally denominated, whether they are reckoned relatively to the north or to a central point in the elevated plains of Tartari."

No. 6. "is a delineation of the country of Bharat, in the fullest acceptance of that denomination. Its nine divisions with Kuru, or Siberia, and the northern parts of Europe, making in all ten districts, were all destroyed by a flood, except one called Gades, which probably includes Spain.

"Some also are of opinion, that, out of the seven dvīpas, six were like-wise overwhelmed by a flood. This circumstance is also noticed in the third volume of the Ayini-Akabari. But I believe that this notion originated with the Pauraniks, who unable to point out these wonderful countries, described in so extravagant a manner in their sacred books, found that the best way was to swear that they had disappeared."

Here the foregoing maps (including projections) were actually drawn by Ancient Indians. Wilford has simply reproduced them with slight modifications only at a few places. Even these modifications are no innovations or additions by Wilford. They are all in toto borrowed from and strictly conform to the Ancient Indians scriptures. Information given by Wilford on pp. 140-41 of Asiatic Researches, Vol. X, further confirms this observation (specially with regard to projection).

To face P. 183



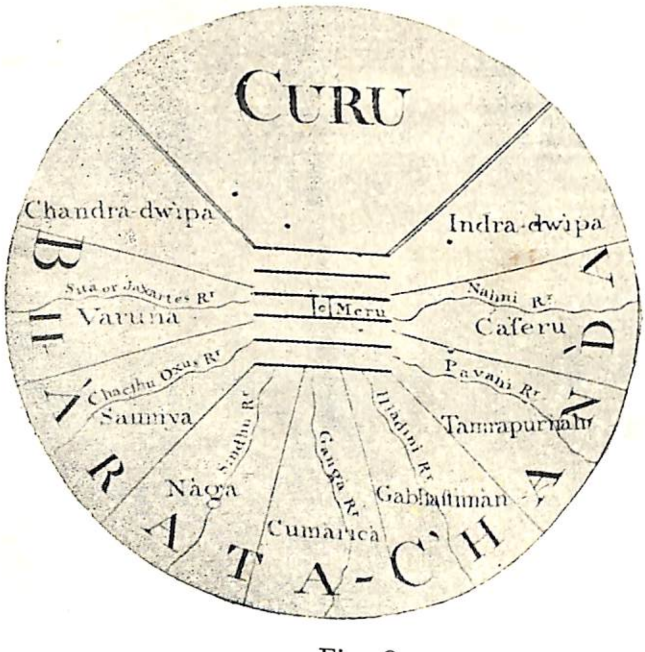


Fig. 8
Wilford's seven dvīpa's and nine divisions of Bhārata.
(Asiatic Researches Vol. VIII, p. 367)

[P.T.O.]

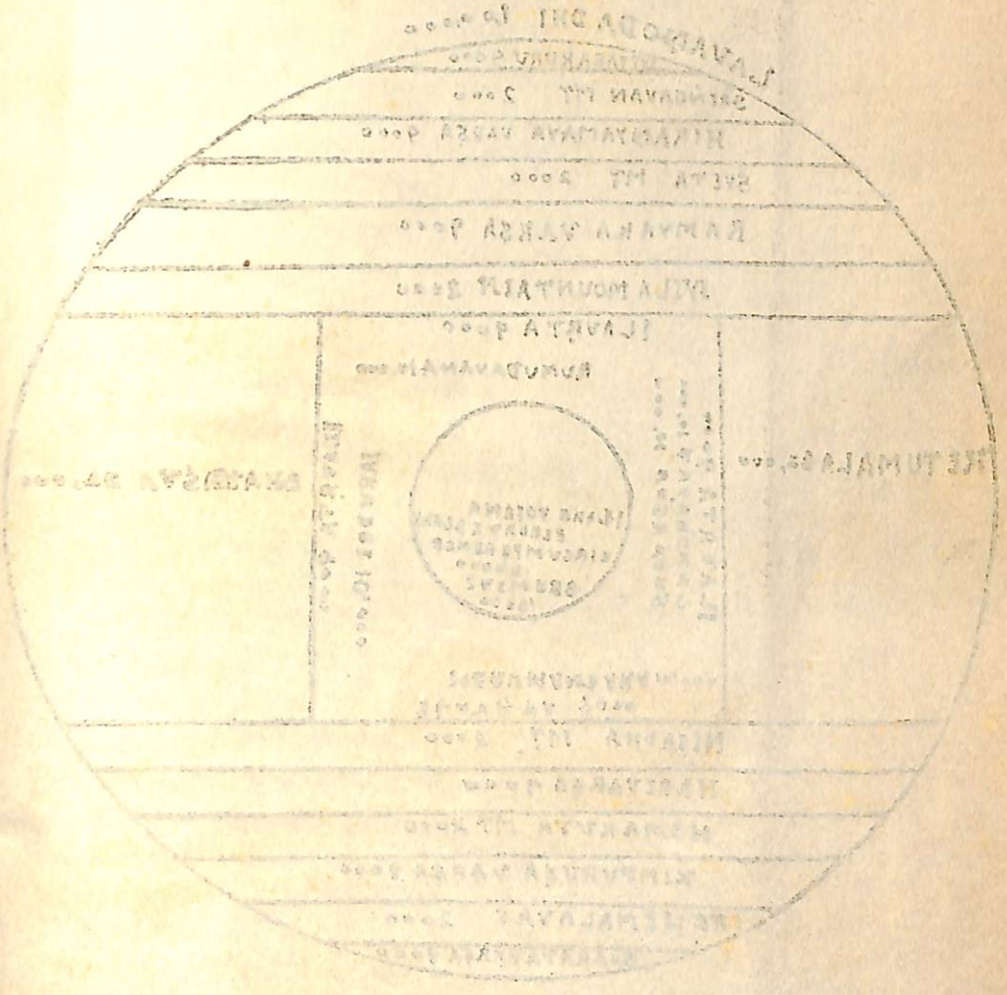


Fig. 9

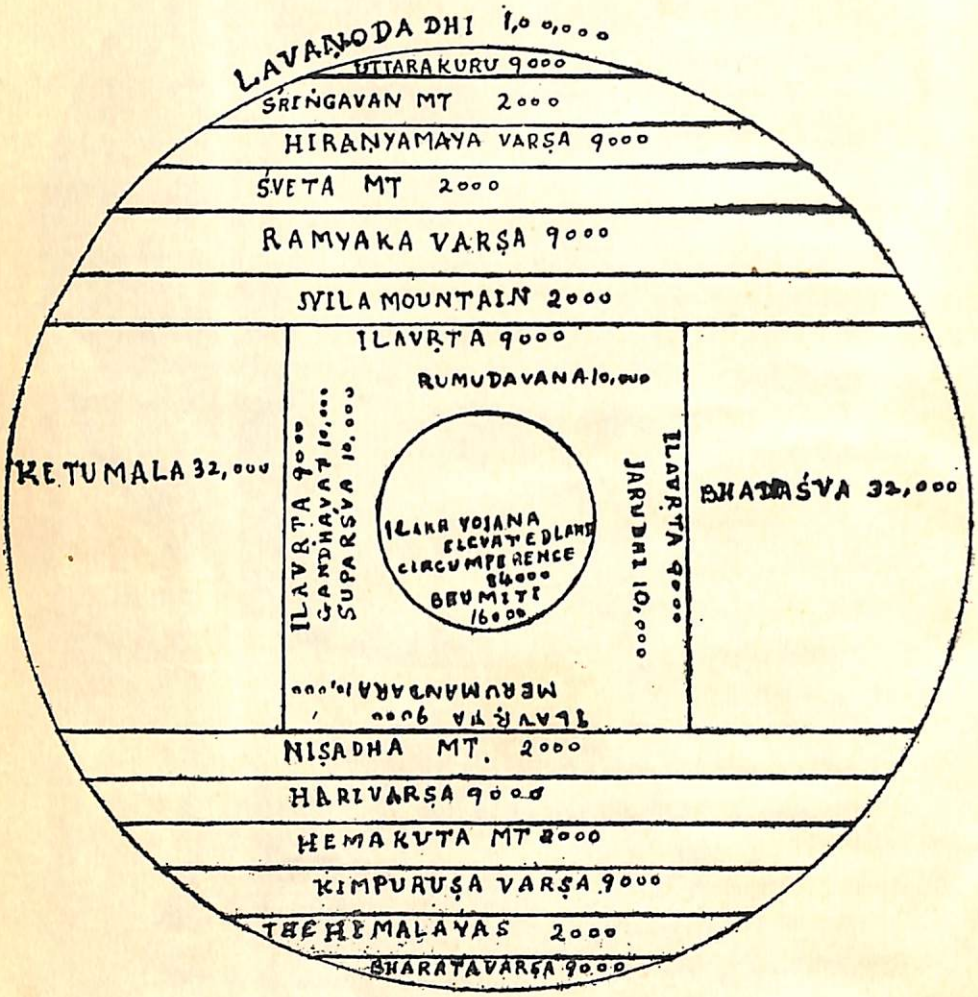
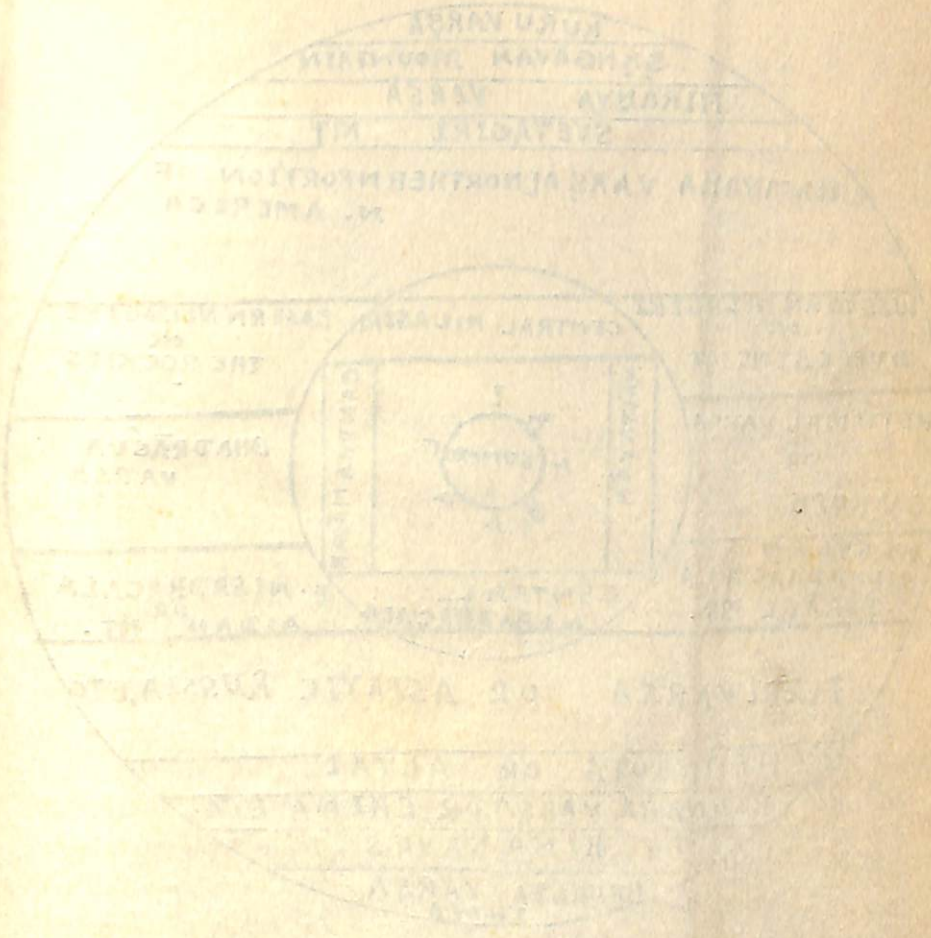


Fig. 9

Jambūdvīpa—its various dimensions in Yojanas [After a map kept in Saraswati-Bhavana Library of Vārāṇaseya Sanskṛta Viśvavidyālaya, Varanasi].



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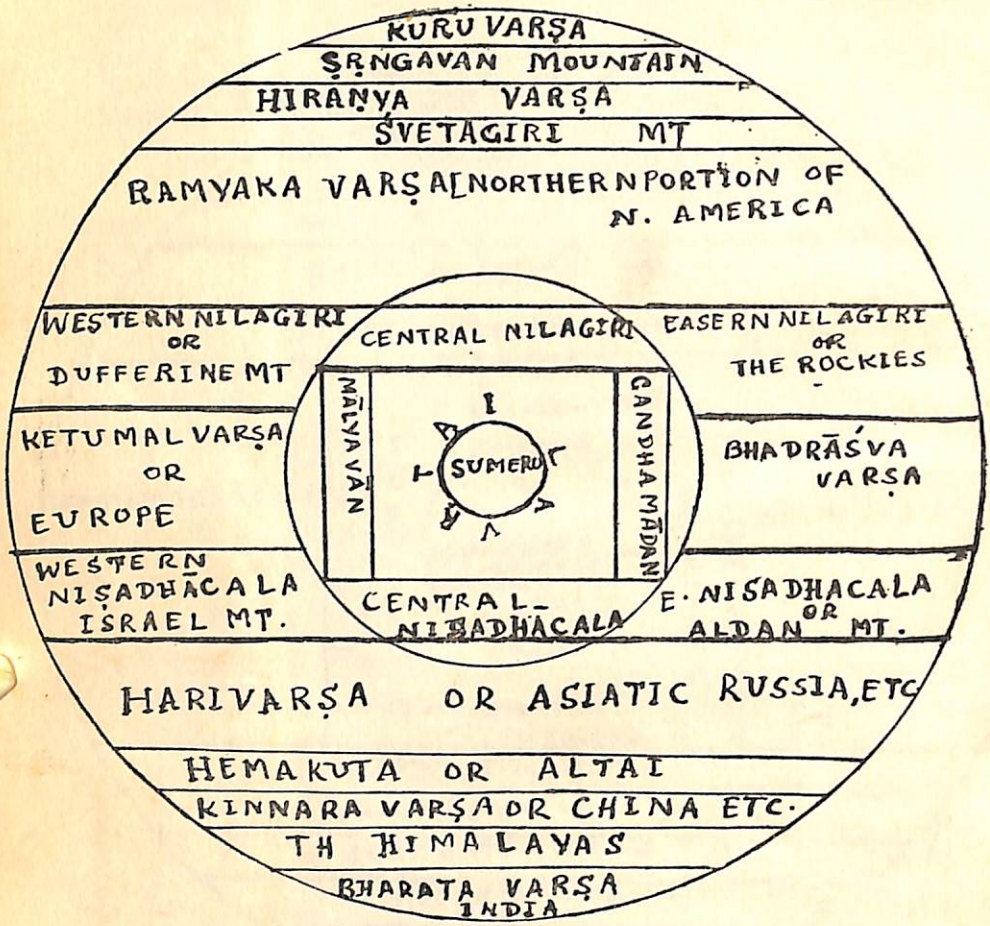

Fig. 10

Jambūdvīpa and its nine varṣas (Identification).

Curiously enough the above representation resembles in toto the world map of modern times drawn on the Oblique Azimuthal Equidistant Projection. From the point of view of its exact centre, it has also something in common with Azimuthal Equidistant Projection Polar case. [After Girija Prasad Divedi].

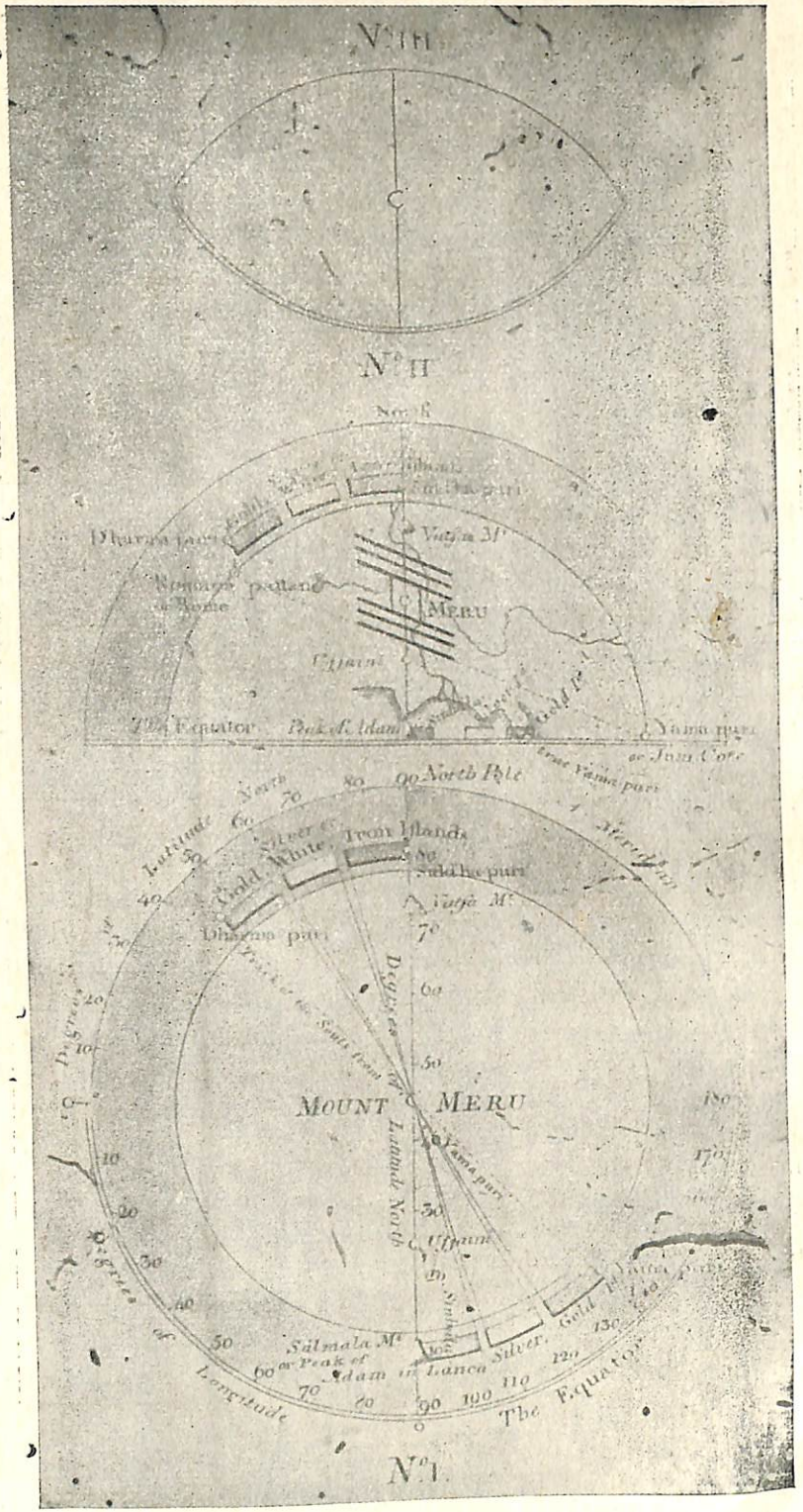

Fig. 12

Wilford's Mt. Meru. (Asiatic Researches Vol. X, P. 140)

Maps No. I, II & III. [P.T.O.]

6-हिरण्यमय[98] (हिरण्यवत्[98a] or हिरण्य)[99] 7-कुरु or उत्तरकुरु (शृंगशाक[100] or शृंगसाह्व, शृंगवत्[101] or ऐरावत[102]) 8-भद्राश्व and 9-केतुमाल. (cf. fig. 7 to 17, 12.). The Mārkaṇḍeya Purāṇa says[103] that Ilāvṛta is situated at the centre and is called Meruvarṣa,[104] Ramyak, Hiraṇyamaya and Uttarakuru lie to the north of Meru,[105] Bhārata, Kimpuruṣa and Harivarṣa are situated to the south of the mountain,[106] and in the east and west lie the other two Bhadrāśva and Ketumāla.[107] Bhārata is the southernmost region (varṣa) separated from the Kimpuruṣavarṣa by the Himavat chain and has the same shape as Uttarkuru resembling a blow.[108] In this connection the Purāṇas[109] have given the dimensions and areas also of the various varṣas, but they are fictitious and totally unreliable, other details appearing to be geographical have little truth, their geographic methodology, however, is correct. The Mārkaṇḍeya Purāṇa furnishes[110] another accurate information that Jambudvīpa is "low on the south and north, and highly elevated in the middle". Ilāvṛta

98. Viśṇu II. 2. 14.
98a. Matsya 113. 64 or 65.
99. Mārkaṇḍeya 53. 34-35. This is also called श्वेतवर्ष (Brahmāṇda) 34.46 (Roychaudhuri) ; Agni 107.7.
100. Matsya 113. 68.
101. Brahmāṇda 34. 47 (Roychaudhuri).
102. Mahābhārata VI. 6.37.
103. Other Purāṇas also furnish the same information e. g. Viṣṇu 2. 2. 15.
104. मेरुवर्षं महा प्रोक्तं मध्यमं यद् इलावृतम्—Mārkaṇḍeya 60. 7.
105. Viṣṇu II. 2.14 ; also other Purāṇas.
106. Ibid II. 2.13 ; also other Purāṇas.
107. Ibid II. 2.24 ; also other Purāṇas.
108. धनु संस्थे च विज्ञेये द्वे वर्षे दक्षिणोत्तरे—Matsya 113. 32 ; Brahmāṇda 35. 33 ; Vāyu 34.31 compare the Mahābhārata VI. 6. 38.
109. e.g. Viṣṇu II. 2.15-16 and their Viṣṇuchit commentary.
110. Mārkaṇḍeya 54.12.

forms the elevated portion. A geographic passage about Kimpuruṣavarṣa occurs thus in the Mārkaṇḍeya Purāṇa.[111]—

"In Kimpuruṣa and seven other countries, O Brāhmaṇa, waters bubble up from the ground ; here in Bhārata we have rain,.....And in these countries the ages do not exist, no bodily nor mental sickness ; nor is there any undertaking involving merit or demerit there."

From this it appears that the Purāṇa might have had some exact knowledge of the topography and physiography of central and northern Asia. "The elevated varṣa in the middle of Jambu-dvīpa may have a reference to the high plateau between the Oxus and Tarim valleys not far from the sandy desert of central Asia—the Bālukārṇava which the Mahābhārata places close to Meru."[112] According to Roychaudhari, Ketumāla, the western varṣa may be identified with the basin of Vaṇkṣu (Oxus) and Bhadrāśva, watered by the river Sītā, with eastern Turkistan and northern China. Uttarkuru in the opinion of N. C. Das,[113] represents countries in northern Asia. Similar uncertainty shrouds the identification of other varṣas. A map is furnished here which has to tell a totally different tale. But it is needless to be involved any more in this question, as already volumes of controversies have centred round it without any conclusiveness.[114]

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111. Eng. Trans. Pargiter 56. 22-26.
112. Studies in Indian Antiquities" by H. C. Roychaudhari, pp. 74-75.
113. "A note on the Ancient Geography of Asia compiled from the Vālmīki Rāmāyaṇa." pp. 67-68.
114. Puraṇic Index by Dikshitar ; N. L. Day and various reputed journals may be consulted with benefit.

Jambudvīpa is said to include other dvīpas (islands) or upadvīpas (subsidiary islands). The Vāyu names them—अङ्ग, यम, मलय, शङ्ख, कुश, and वराह—48. 14. These are discussed in Asiatic Researches by Wilford, vols. VIII, X and XI and III. According to the Bhāgavata, the upadvīpas are

Explanation of the adjoining [plate No. II Asiatic Researches Vol. XI, P. 131) (in Wilford's words).

"For the illustration of this subject, I have annexed a map of the north west quarter of the old continent, from the Puranas ; and the only additions I have presumed to make, are first a rough delineation of the western shores of Europe; and secondly the polar circle."

Here Indradvīpa, Sthuladvīpa, Romaka Sea and other details are shown. Passages following the above quotation are extremely interesting, they may be further consulted for having a searching insight into the Pauranic geography and accompanying cartography.

To face P. 185

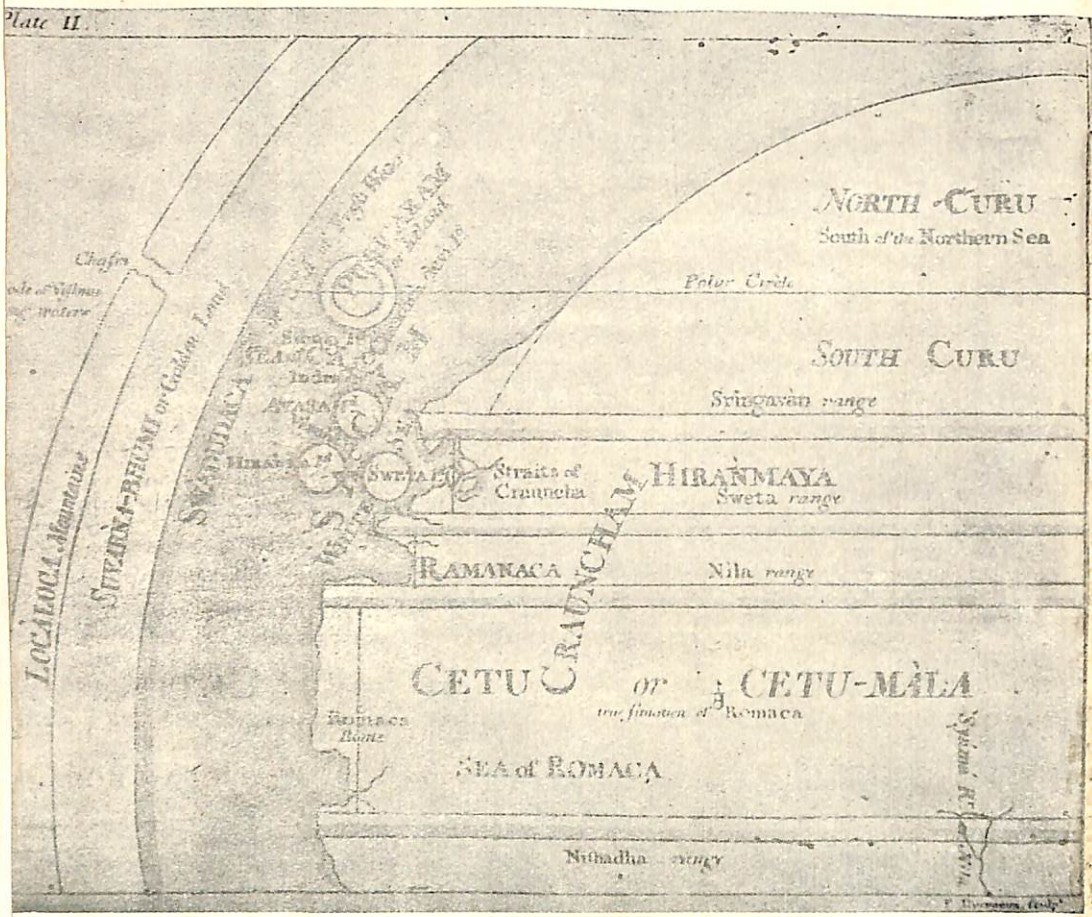

Fig. 13

Wilford's Identification of divisions of Jambu in Europe etc.

(Asiatic Researches Vol. XI, P. 131) [P.T.O.]

Other dvīpās—(continents) — Various Purāṇas[115] have discussed the geography of other dvīpas—Kuśa, Śaka, Krauñca and the like also in some detail. They have enumerated the varṣas or regions of each and named their important mountains (वर्षपर्वत,) chief rivers and furnished some other geographic facts. But it is almost impossible to thrash out any real tangible geography from them in modern terms. Inspite of their scientific and logical inquisitiveness and correct approach, they have failed to provide anything of plausible geography, as generally their accounts seem to be based on tradition, hearsay, mere guess work and legends without any reference to painstaking and actual exploration travels, investigation and collection of material. (cf. fig. 13.)

Mountain system of the World—According to the Purāṇas the whole mountain system of the world centres round the Meru which has been described to be situated in the middle of Ilāvṛta varṣa.

From their own point of view, the Purāṇas have recognised in general five categories of mountains : 1—Central mountain or Meru, 2—Viṣkambhaparvatas (subjacent[116] mountains), 3—Varṣa Parvatas (sub-continental ranges), 4—Kulaparvatas (principal chains), and 5—Maryādā Parvatas (boundary mountains). The Brahma, Śiva and Viṣṇu Purāṇa and others have recognised a sixth class designated as Kesara-parvatas (Filament mountains).[117]

स्वर्णप्रस्थ, चन्द्रशुक्ल, आवर्तन, रमणक, मन्दहरिण, पाञ्चजन्य, सिंहल and लङ्का—V, 19. 30. Again Wilford may be consulted in the above-mentioned volumes.

115. Garuda chapter 56, Viṣṇu II. 4 ; Matsya chap. 122, Agni 118 ; Brahmāṇda chap. 19 ; Vāyu chapters 33 and 49.
116. This and the following English equivalents are borrowed from Dr. H. C. Roychaudhuri.
117. Brahma 18. 33 and Śiva (uttarārdha—V. 17. 23-25) : Viṣṇu II. 2. 27-30.

Meru is described in some detail and a few dimensions are also given pertaining to it.[118]

2—Viṣkambhaparvatas—(subjacent mountains)—They are said to be four in number—Mandara in the east, Gandhamādana in the south, Vipula on the west and Śupārśva on the norths.[119]

3—Varṣa Parvata (sub-continental ranges).[120] These are six in number. Between Kuru and Hiranyamaya varṣas stretches Sṛṅgī (Sṛṅgavat) : between Hiraṇyamaya and Ramyaka varṣas the Śveta mountain ; between Ramyaka and Ketumāla and Bhadrāśava varṣas, the Nīlagīri mountain ; between Harivarṣa Bhadrāśava and Ketumāla varṣas, the Niṣadha ; and between Harivarṣa and Kīnnaravarṣas, the Hemakūta ; and between Bhārata and Kīnnaravarṣa, lies the Himāvat (the Himalayas). The Sṛṅgī, Śveta, Nīla, Niṣadha, Hemakuta and Himāvat are said to be the mountains of Uttarakuru, Hiranmaya, Ramyaka, Hari, Kinnara and Bhāratvarṣas respectively, since the Meru is the varṣaparvata of Ilāvṛta, there may be said to be seven varṣaparvatas in all.

4—Kala-parvatas (principal chains)—According to the Purāṇas every varṣas, has got seven principle ranges[121] group mountains or class mountains. In Bhārata varṣa these are the following varṣa parvatas—Mahendra, Malaya, Sahya, Suktimān, Ṛkṣa, Vindhya and Pāriyātra.[122]

5—Maryādā Parvatas—(boundary mountains) The four petal like sub-continents Uttarakuru, Bhārata, Bhadraśwa, and Ketumāla are far removed from each other. These are separated from Ilāvṛta and other inner varṣas by the ranges called Maryādā parvatas or boundary mountains, which have

118. Mārkaṇḍeya 54. 15 ; Viṣṇu II. 2. 8.–10 and other Purāṇas.
119. Viṣṇu II. 2. 18 ; and other Purāṇas.
120. Viṣṇu II. 2. 11 ; Mārkaṇḍeya 54. 9 and other Purāṇas.
121. Agni 108. 32.
122. Viṣṇu 2. 3. 11 ; Mārkaṇḍeya 57. 10-11.

been said to be eight in number. The Jaṭhara and Devakūta are situated on the east side of Meru and mark off Ilāvṛta from Bhadrāśwa[123] ; Niṣadha and Pāriyātra on west separating Ilāvṛta and Ketumāla ; Kāilasa and Himavat on the south lying between the central varṣa (Ilāvṛta) and Bhārata and the last pair Sṛṅgavat (Triśṛṅga) and Jārudhi (Rudhira) is situated on the north and separates Uttarakuru from the remaining portion of Jambudvīpa.[124]

From the above enumeration a little confusion may creep in regarding the Maryādā Parvatas and varṣa-parvatas. On this point Dr. Roychaudhuri observes,[125] "The distinction between the Maryādā Parvatas and the Varṣaparvatas is not easily understood, and some of the former, notably Himavat and Sṛṅgavat (sṛṅgī) actually figure as varṣaparvatas. It is however, to be noted that the name Maryādāparvata is given to mountains on all sides of the Meru which separate the central Varṣa or Varṣas from the four outer mountain sub-continents. Varṣa parvatas on the other hands, include Meru itself and the ranges separating the northern and southern (but not the eastern and western) varṣas from one another. All of them with the exception of Meru, are represented as running from east to west and extending to the sea. That there is overlapping in regard to the northernmost ranges is what may naturally be expected. The innermost Varṣa parvata, viz : Nīla and Niṣadha, lying immediately to the north and south of Meru, join two other ranges, viz : the Mālyavat and Gandhamādana (No. 2) which are associated with the eastern and western Maryādāparvatas respectively, and completely shut off Ilāvṛta from the rest of the world. They are the quadrangular mountains referred to by Alberuni.

6—Kesaraparvatas (the Filament mountains)—These are also the mountains situated round Meru (which is known as

123. Mārkaṇḍeya 54. 22-26.
124. Agni 108. 5 ; Viṣṇu II. 2. 40-44.
125. "Studies in Indian Antiquities," p. 98.

"the seed vessel of the earth") and in between other major ranges mentioned above including the Meru, on the east we have Śitāmbha, Kumuda, Kurari, Mālyavāna and Vaikaṅka ; on the south Trikuta, Śiśira, Pataṅga, Rucaka and Niṣadha;[126] on the west, Śikhivāsa, Savaidūrya, Kapila, Gandhamādana and Jārudhi ; and on the north Śaṅkhakūta, Ṛṣabha, Hansa, Nāga and Kālāñjana.[127] But there is a great difference between these names and those given in the Śiva Purāṇa.[128]

It is peculiar that sometimes a Purāṇa itself confuses between the two nomenclatures, or in other words it does not strictly adhere to connotations or denotations assigned to a specific generic term. For example the Liṅga Purāṇa in its chapter 53 has confused between the two terms—Varṣaparvatas and Kulaparvatas and uses one for the other.

Geography of Bhāratavarṣa [India]

Regarding the naming of the country Bhāratavarṣa, the Purāṇas are not unanimous. They have promulgated three most important theories in this respect. According to the first the country derives its name from the mythical monarch Bharata[129] who was a decendant of Svāyambhuva Manu and son of Ṛṣabha. The second theory states that Bharata was an epithet of Manu himself and the country was christened after him.[130] According to the third, "We find a

126. II. 2. 27-28.

127. II. 2. 29-30.

128. Uttarārdha, V. 17. 23-26.

129. ततश्चभारतंवर्षमेतल्लोकेषु गीयते । भरताय यतः पित्रा दत्तं प्रतिष्ठितं वनम् ।—Viṣṇu, II, 1. 32.

हिमाह्वयं दक्षिणं वर्षं भरताय न्यवेदयत् ।
तस्मात्तद् भारतं वर्षं तस्य नाम्ना बिदुर्बुधाः—
Brahmāṇda 34.55 (Roy Chaudhuri)

130. भरणाच्च प्रजानां वै मनुर्भरत उच्यते ।
निरुक्तवचनाच्चैव वर्षं तद भारतं स्मृतम् ।—
Matsya 114. 5 ; Brahmāṇda 49. 10 (Roy Chaudhuri).

tradition in the Vāyu Purāṇa that the centre of Jambudvīpa is called Bhāratavarṣa, which means those who acquire something and nourish themselves."[131]

Dr. Roychaudhuri makes a fourth suggestion,[132] "The name of the country south of Himavat was derived, not from the mythical Bharata of the Purāṇas, but from the historical Bharata tribe (Cf. Bharati Prajā of Vayu 45. 76 ; Bhāratī Santatiḥ Viṣṇu P. II. 3. 1) who plays so important a part in Vedic and epic tradition. The political domination of the greater part of India by 'seven Bharatas' is testified to by Buddhist texts. The cultural supremacy of the tribe is equally clear from the evidence of the ṚK and Yajus Sanhitas, the Brāhmaṇas and the great epic which bears the name of Mahābhārata."

Out of these four theories, the first, second and the fourth appear to possess the greatest plausibility and have most logical foundation.

So far as general geography of Bhāratavarṣa is concerned, as given in the Purāṇas, it must be observed at the very outset, it is a medlay of accurate and legendary facts both.

Denotation of Bhāratavarṣa

This is the southernmost varṣa, bordered by the Himavat or the Himalayas in the north and by the seas in the south, the general English nomenclature for which is India. But the Paurāṇic term Bhāratavarṣa not only includes the territories occupied by the combined countries of Pakistan and modern Bhārata (India), but also some adjacent territories in the south of the Cape Camorin and in the southeast Asia. The term was actually applied for the entire stretches of numerous c untries for which now-a-days the appellation "Greater India" is used. The Paurāṇic Bhāratavarṣa stretched from the northwest and north Himalayas to the southeast Asian

131. Cf. Alberuni (I, p. 251).
132. "Studies in Indian Antiquities." p. 79.

Archipelago including present Indonesia, Indo-China and Borneo.

This statement is based on the fact that the Purāṇas have recognised nine-fold divisions of their Bhārata-varṣa.[133] About them the Mārkaṇḍeya Purāṇa says that these are the divisions "which must be known as extending to the ocean but as mutually inaccessible."[134] In other words several divisions are separated by oceans between them.

The Mārkaṇḍeya Purāṇa enumerates,[135] those divisions in the following lines—

इन्द्रद्वीपः कसेरुमांस्ताम्रपर्णो गभस्तिमान् ।
नागद्वीपस्तथा सौम्यो गान्धर्वो वारुणस्तथा ॥
अयं तु नवमस्तेषां द्वीपाः सागर-संवृताः ।
योजनानां सहस्रं वै द्वीपोऽयं दक्षिणोत्तरम ॥

The Garuda[136] and Vāmana Purāṇa[137] read Katāha and Sinhal instead of Saumya and Gāndharva. Again the Skanda[138] and Vāmana[139] name the ninth as Kumārikā (or Kumārikā Khaṇḍa). Also the latter[140] calls it Kumāra. Thus the nine sub-divisions are : 1—Indradvīpa, 2—Kaśeruman, 3—Tāmraparṇa, 4—Gabhastimān, 5—Nāgadvīpa, 6—Katāha (if not Saumya), 7—Sinhala (if not Gāndharva), 8—Vāruṇa and 9—Bhārata or Kumāra or Kumārikā Khaṇḍa.

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133. The Viṣṇu II. 3. 6 ; Garuda 55. 5 ; Matsya 114. 7 ; Brahma 19-7 etc.
134. Mārkaṇḍeya 57. 5 ; Generally in other Purāṇas it is "द्वीपः सागर-संवृतः" e. g. Viṣṇu 2. 3. 7 which is better.
135. 57. 6-7.
136. 55. 5.
137. 13. 10-11.
138. Maheśvara Khaṇḍa, Kumārikā Khaṇḍa 39. 68-69 and 111.
139. Maheśvara Kumārika Khaṇḍa 39. 69.
140. Vāmana 13. 11.

According to the Viṣṇu Purāṇa[141] the ninth division measures 1000 yojanas from the north to south (it is approximately correct dimension of India proper, if a yojana equals 2 or 2.5 miles). In the east it is flanked by the country of Kirātas[142] and on the western border lies the land of Yavanas.[143] In the following verse it is stated that this division is inhabited by the Brāhmaṇas, Kṣatriyas, Vaiśyas and Śudras, from which we can infer with certainty that it refers to India proper. This leads us to fortify our belief beyond the least shadow of doubt that the Paurāṇic term Bhāratavarṣa has wider denotation than the territory of India proper.

Now we can take up the other eight divisions[144] of Bhāratavarṣa and investigate what actual lands or regions they signify or how far they conform to geographic reality or contain fabulous accounts.

1. Indradvīpa—There are two opinions regarding the identification of this division. According to one it is a region lying between Laṅkā and Mahendra mountains. The other opinion is that it is Burma. On various grounds the latter appears to be more convincing.

2. Kaśerumat (or Kaśeru)—It was either to the east of the Madhyadeśa or between the Mahendra and Śukti.

3. Tāmraparṇa, Tāmraparṇī or Tāmravarṇa—This was an area lying in the basin of modern river Tāmraparṇī.

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141. II. 3. 8.
142. Mentioned in the above verse, N. C. Das has identified it with some area on Assam border near Burma. "A note.....Rāmāyana," p. 55. It appears to be correct though Dr. Roychaudhuri differs from it—Cf. "Studies in Indian Antiquities," p. 86, footnote 5.
143. May signify easternmost point of Greek stretches.
144. For detailed study Cf. "Studies in Indian Antiquities," by Dr. Roychaudhuri, "Geography of Ancient India," by A. Cunningham and others.

This is the view discussed by Dr. Roychaudhuri, which appears to be most logical and convincing. Some scholars believe it to be some portion of Ceylon, which perhaps lacks foundation.

4. Gabhastiman—This area lay either between the Ṛkśa. and Malaya mountains or to the south of the Madhyadeśa.

5. Nāgadvīpa—It is believed to be Jaffana peninsula. According to Tamil traditions it was the domain of Nāga King.

6. Saumya is most probably Malaya peninsula. But if the better reading Katāha is accepted instead of it, the latter can be identified with the present part of Kedah in the Malay Peninsula.

7. Gāndharva—Alberuni places it to the northwest of of Madhyadeśa, but it may be Gāndhāra. If the other reading Sinhala is accepted, it no doubt denotes present Ceylon or a portion of it.

8 Vāruṇa—Abul Fazl took it to be the western part of a region lying between the Western Ghats and the Vindhyas. But this view appears to be untenable. Dr. V. S. Agrawal[145] and Rāhul Sāṅkrityāyana[146] identify it with present Borneo, which seems to be most convincing.

There appears to be two reasons why the entire territory covered by all the nine divisions was called Bhāratavarṣa— 1. All were adjacent areas and formed a splendid geographic contiguity and in terms of modern geopolitics were a "compact tract" ; and 2. the whole region was colonised or inhabited and dominated by the people from India proper (भारती यत्र सन्ततिः)[147], or of Indian descent, and thus possessed geographical and racial affinity and cultural homogeneity.

145. "कटाह द्वीपकी समुद्र-यात्रा", विश्वभारती, वैशाख-आषाढ़ २००१ वि०

146. भारतीय-संस्कृति, भाग २, पृ० ७१।

147. Viṣṇu II. 3. 1.

The Brahmāṇda Purāṇa marks off the most logical geographical divisions of India proper. It[148] has described the seven regions of Kumārī dvīpa, namely, 1. Madhyadeśa, 2. Audicya, 3. Prācya, 4. Dakṣiṇāpatha, 5. Aparānta, 6. the Vindhyan region and 7. the Parvatāśraya (the Himalayan tract.)

General Geographic Details of India Proper

Almost all the Purāṇas furnish some details of Indian geography.[149] They have quite accurately mentioned the mountains, rivers and their sources. In addition, they have cummulative or community or nationality names of the inhabitants of various regions.

Mountains of India Proper—In a preceding paragraph a reference has already been made to the Kulaparvatas of Bhārata. These included Mahendra, Malaya, Sahya, Śuktimat, Ṛkṣa, Vindhya and Pāriyātra and formed the chief ranges of the country. Regarding their identification also much controversy has accumulated.[150]

Mahendra—Without entering into any discussion, we can safely use the conclusion of others to state that it may imply 'the entire chain of hills extending from Ganjam to Tennevely[151]. In other words, it is the Purvighats.

Malaya—It is identified with the portion of the western ghats extending from the Nīlagiri to the proximity of Cape Comorin south of the river Kaverī. It is the same mountain of Sanskrit literature with which tradition has attached so much of Romanticism.

Sahya—Regarding this mountain there rages no controversy and it has been accurately identified with the northern

148. Nadyadi-Varṇana section, 34.64 (Roychaudhuri, p. 92).
149. Visnu II. 3. 10-26.
150. Vide "Studies in Indian Antiquities"—Dr. Roychaudhari and "Geography of Ancient India" by A. Cunninghum.
151. "Studies in Indian Antiquities"—Dr. Roychaudhuri, p. 109.

portion of the western ghats from the Tapti down to the Nīlagiris.

Śuktimat—The identification of this mountain is shrouded in the greatest obscurity and extremely divergent opinions are held by the scholars. Dr. Roychaudhari hazards the following suggestion, "The name Śuktimat was probably applied to the chain of hills that extends from Śukti in 'Raigarh (M. P.) to the Dalma hills in the Manbhum drained by Kumari, and perhaps even to the hills in the Santhala Parganas washed by the affluents of Babla."[152]

Ṛkṣa—In the Purāṇas sometimes it has been confused with the Vindhyas. Perhaps it implies the chain of the Central Vindhyas near about the central Narmadā region.

Vindhyas—Though frequently interchangeable with the denotation of the Ṛkṣa, embraced the chains from Gujarata to Gaya district or when used in restricted sense indicated the mountain range south of the Narmadā.

Pāriyātra—Dr. Roychaudhari shares the view of Pargiter that it denoted the modern Vindhyan range, west of Bhopal, together with the Aravali mountains.

In addition to these principal mountain chains, the Purāṇas have enumerated a large number of smaller mountains extending in the vicinity of the former. But here it would be a total deviation from the subject proper to throw any light on them.

Shape of India as given in the Purāṇas—The Purāṇas have divergent and contradictory opinions regarding the shape of India, but occasionally they have described the true shape also of the country. The Mārkaṇḍeya Purāṇa[153] has given much satisfactory description of the figure. According to it the country is "constituted with four fold conformation चतुः सस्थानसंस्थितम्" "on its south, west and east is the great ocean, the Himavat range stretches along on its north like

152. Ibid., p. 120.
153. 57. 58-59.

the string of the bow." The bow like figure (semicircular ; it would be extremely accurate description, if we take it to be a strung bow) of Bhārata has already been referred to.[154] The Mārkaṇḍeya speaks of the conformation of India as that of a tortoise, and it is technically styled as कूर्मनिवेश. The Nārada Purāṇa has described this Kūrmaniveśa in detail, mentioning various countries in different directions.[155]

Miscellaneous Geographic Facts—The Mārkaṇḍeya Purāṇa reveals that it knew how to give a geographic description of a river. In chapter 56 it furnishes a good geographic account of the origin of the Gaṅgā, its course, countries and forests flanking it. Prior to it, vegetations and different types of agricultural products are mentioned in detail.[156] The Viṣṇu Purāṇa[157] also enumerates several types of food grains and other agricultural products. It has recognised two classes of agricultural products—1. ग्राम्य (cultivated) and 2. आरण्य (wild or uncultivated). The Brahmāṇda says[158] that all kinds of domestic and forest fauna are found is Plakṣadvīpa.

In the Śiva Purāṇa occur the following lines[159]—

प्रति लिङ्गं तु संस्थाप्य क्षीरं वृक्षसमुद्भवम् ।
स्थितं बुद्ध्वा उत्सृज्य लिङ्गं ब्रह्मशिलोपरि ॥

Now it refers to milk of trees ; did the Paurāṇic people know the preparation of some objects from that ? Thus were they acquainted with rubber and any type of manufacture (for

154. Vāyu 34.31 ; Matsya 113. 32.
155. Compare Vṛhatsanhitā Chapter 14 (Nakṣatrakūrmādhyāya) ; and the subsequent sections of this investigation "Jain Text" and "Buddhist scriptures". Also Svarodaya (in the 9th chapter of the present work).
156. Mārkaṇḍeya 49. 65-73.
157. Chapter 6, MND, p. 26. Compare Vāyu 8. 133-156 ; Vṛhatsanhitā सत्यजातक Chapter 39.
158. Pūrvabhāga 10.28.
159. Uttar Vāyavīya Sanhitā 7, Khaṇḍa 2, Chapter 36.33.

example playing balls and the like) from it ? From the above verse one thing is certain that they knew collection of vegetable milk. Thus just possible rubber and some sort of rubber manufacturing might have been known in the Paurāṇic times. This assertion is based on the following arguments—

(i) Lakh or lac was known in India from very early times (Cf. लाक्षागृह of the Mahābhārata). It makes it evident that vegetable secretion was collected on a large commercial scale in India near about or prior to the age of the Mahābhārata. It is just possible, that balls[160] were made of the milk of trees of rubber, for it is an indigenous plant of India also (growing wildly in Assam and the south).

(ii) Rubber might have been imported in India proper from its most congenial original home—Saumya or Katāh or Malaya peninsula—forming a part of India.

(iii) Rubber is a tropical plant.

In the Paurāṇic age science of mineralogy was much developed. The Garuda-purāṇa contains a separate Sanhitā on it, forming its chapter 68-80. These chapters demonstrate that several treatises existed on this science prior to the Purāṇas and there existed a great tradition of experts, who were wellversed in the knowledge of occurrence, mode of exploitation, distribution and other industrial aspects of minerals and gems.

In the Liṅga Purāṇa we come across a chapter (50) entitled as "भुवनविन्यासोद्देशस्थानवर्णनम्." It gives the number and population of towns and cities of different communities (Dānava, Kinnara, Ṛṣi etc.). It has attempted to furnish several types of Statistics. It gives a glimpse of urban geography and some sort of census also. The Skanda

160. Ball playing was known to Pāṇini (700 B. C.), the Mahābhārata (400 B. C.) and Bhāsa (200 B. C.) and Kālidāsa (100 B. C.).

gives[161] the number of grāmas in various countries. But if a grāma is taken to mean a village, the entire implication does not seem to possess consistency and becomes vague. Hence does this term mean "population" ? Then does it indicate some conception of census ? In a certain context Dr. V. S. Agrawal has explained[162] grāma to imply coins of income or land revenue. His meaning appears to apply to these verses more accurately.

The ancient Indians definitely knew to keep their population stationary just like France which maintained its population constant during 1906—1960.[163] In this connection the Viṣṇu Purāṇa says—अपसर्पिणी न तेषां वैन चोपसर्पिणी द्विज.[164] This Purāṇa further speaks[165] of a region where "communism" prevailed and perfect economic, social and religious equality reigned supreme—

अधमोत्तमौ न तेष्वास्तां न वध्यवधकौ द्विज ।
नेर्ष्यासूया भयं द्वेषो लोभादिको न च ॥
महापीतं वहिर्वर्षं धातकी खण्डमन्ततः ।
मानसोत्तरशैलस्य दैवदैत्यादिसेवितम् ॥
सत्यानृते न तत्रास्तां द्वीपे पुष्कर-संज्ञिते ।
न तत्र नद्यः शैला वा द्वीपे वर्षद्वयान्विते ॥
तुल्यवेशास्तु मनुजा देवास्तत्रैकरूपिणः ।
वर्णाश्रमाचारहीनं धर्माचरणवर्जितम् ।
त्रयीवार्ता दण्डनीतिशुश्रूषारहितं च यत् ॥

Here the commentator explains "तुल्यवेशा" as implying "having equal comfort" (economic resources).[165a]

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161. Maheśwara Khaṇda 39. 125-165.
162. "भारत की मौलिक एकता" p. 179.
163. The New Europe, p. 209 by W. Filzgerald 1948 and Statesman Yearbook.
164. II. 4-13.
165. II. 4. 78-83.
165a. Vide the Matsya 122.99 to 101.

Various Purāṇas[166] evince a splendid conception of urban geography. The Brahmāṇda Purāṇa[167] has recognized the ten types of roads—1. दिशामार्ग (international trunk roads width 80 cubits or 120 ft.); 2. ग्राममार्ग (leading to another village 80 cubits); 3. सीमामार्ग (border roads 40 cubits); 4. राजपथ (city roads 40 cubits); 5. शाखारथ्या (branch roads 16 cubits); 6 रथोपरथ्या (vehicular branch roads 12 cubits); 7. उपरथ्या (smaller ones—8 cubits); 8. जंघापथ (4 padas or feet); 9. गृहान्तरपथ (internal streets 3 padas) and 10. वृतिमार्ग (above 6 padas). The Vāyu[168] mentions eleven types. The seven categories are common to both the Purāṅas, after the seventh the latter lists—8. घण्टापथ (4 padas or ft.); 9. गृहान्तरपथ 3 padas ft.); 10. वृत्तिमार्ग (½ pada foot-tracks or perhaps the reading is corrupt) and 11. प्राग्वंश (one pada ft.).

There occur profuse references in the Purāṇas which point beyond any doubt that the Pauranics had definitely fair conception of commercial geography, for example the Viṣṇu[169] speaks of Kāmboja horses and the Matsya[170], of Nepal blankets.

Exploration, colonisation and knowledge of foreign lands—The Pauranic era constitutes a period of Indian history which saw most vigorous activities in the realm of international trade relationship, colonisation and colonial expansion and establishment of Indian political authority in the foreign lands.[171] The averment is based on external evidences of

166. Brahmāṇda Chap. VII; Agni Chap. 106; Matsya Chap. 130; Vāyu Chap. VIII.
167. Pūrvabhāga VII. 112 to 115.
168. VIII. 118 to 121.
169. V. 29.32
170. 22.86
171. "The Age of Imperial Unity" Chapters 24 & 25 and "The Classical Age" Chapters 23, 24 edited by R. C. Majumdar. Also "Ancient Indian Colonies" by R. C. Majzumdar, Vol. I and Vol. II,

foreign sources, archaeology, numismatic findings and other antiquarian discoveries. Even if we confine to the internal evidences of the Purāṇas, we have got more than adequate testimony to corroborate the aforesaid assertion.

Here only internal evidences are being cursorily reviewed. The nine divisions of the Bhāratavarṣa recognised invariably by all the Purāṇas have already been discussed. Their inclusion in India unmistakably points that those south east Asian regions had geographically, politically, commercially and culturally almost merged their identity with India proper and Indians had spared no pain to comb them thoroughly from land and ocean routes both—the former passing through Yunnan and Burmese borders, and the latter along the coast and midocean. Of course the colonisers, traders, religious missionaries and other travellers had limitations of scientific knowledge and transport difficulties. And despite all, in due course they had reached up to Japan.

Purāṇas also mention Vāhlīka, Śaka, Chīna, Yavanas, Pārsika, Musal, Romaka and various other western countries.[171a] Therefore, they must have known African countries and several European lands. On the internal testimony of the Purāṇas Wilford has tried to show that there had occurred vast migration and colonisation of Indians in the west, from Madagaskar, Abyssinia, Egypt right up to British Isles and Iceland.[172] This must have necessitated requisite oceanic and land exploration also.

Astronomical Treatises

This class of work, no doubt, contains some scattered information on general and regional geography of the world and India, both in the chapter devoted to 'Bhuvanakośa', but it should not detain us, and a sweeping reference to that is sufficient for the simple reason that astronomical treatises

171a. Mārkaṇḍeya 57. 33-57; Garuda Chap. 55; Bhāgavata IX. 20-24; Padma Ādi 6.58 (for Mosal).

172. Asiatic Researches, Vols. III, VIII, X and XI.

have generally derived their knowledge of the aforesaid branches of geography from the Purāṇas, which we have already examined in some detail.

The encyclopædic work Vṛhatsanhitā, however, deserves some special notice. It contains a full-fledged chapter (39) designated as सस्यजातक (science of food crops or agricultral products). It is thus a chapter on Agriculture corresponding to that found in modern geographical treatises. It has divided the crops into two categories ग्रीष्मसस्य (summer crops known as Ravi) and शरत्सस्य (winter crops known as Kharif). It is evident that the chapter is concerned with India only.

The Vṛhatsanhitā has got four Chapters—79, 80, 81 and 82 on gems or mineralogy. In these the author has tried to present geography, economic geology and commercial facts concerning diamond, pearl, ruby and emerald and acknowledges the existence of prior reatises and authorities on this branch of knowledge.

Architectural Sources

From these texts we collect valuable information on urban and political geography. The Mānasāra has discussed the various aspects of villages, town and cities in detail and classified them in various categories. Dwelling on the arteries of communication, it has recognised five types of roads[173] रथ्या (carriage road), वीथी (streets) मार्ग (smaller roads) महामार्ग (large road) and क्षुद्रमार्ग (lanes) and discussed the width of each. It has correlated ethnic or group conception or consciousness with towns and their planning, that is, has envisaged different classes of towns for different communities and in this connection has dealt with inhabitation pattern also.

The same subject is dilated on in the Mayamatam.[174] It has recognised classifications of towns from geographical

173. Chapter IX.

174. Chapters IX, X.

and strategic point of view also. It speaks of seven types,[175] of civil towns 1. राजधानी 2. नगर 3. खेट 4. खर्वट 5. पत्तन 6. शिविर and 7. सेनामुख.

Rājadhānī is the metropolis situated in the centre of the nation, flanked by a river or rivers and abounding in civilised population and containing the residence of the ruler.[176] *Nagara*[177] is the market or commercial centre, most probably a nodal point of land area only. *Kheta* contains the population of low classes (Śūdras) and encircled by rivers and mountains.[178] *Kharvataka* is the town encompassed by hills on all sides and inhabited by all classes of people.[179] The town which is situated on the sea shore, deals with commodities imported from foreign lands, all kinds of sales and purchases, is full of various kinds of riches and is inhabited by all classes of people is known as *Pattana*[180] *Śivira*[181] is the town which is situated near a foreign territory and has been specifically created for military purposes, and the military town situated near rivers and mountains and having every kind of defence arrangement and regal residence is styled as *Senāmukha.*[182]

The Mayamatam further mentions seven types[183] of forts or protected or military towns or cantonments. One which is established by the king is स्थानीय another encircled by rivers or seas on the right and the left, populated by traders and other classes bears the name द्रोणमुख such a class of towns situated near a village is विडम्बम्. A fort town, in a forest populated by all the four classes is designated as कोल्मकोलम्;

175. Ibid. Chap. X.
176. Ibid. X. 19.
177. Ibid. X. 25.
178. Ibid. X. 26.
179. Ibid. X. 27.
180. Ibid. X. 28-29.
181. Ibid. X. 30.
182. Chapter X. 30-31.
183. Ibid. X. 23-36.

one which is full of all kinds of artisans is निगम. स्कन्धावार is that which is full of rivers, hills and forests and regal residence together with the dwellings of other classes. Another situated in the proximity of the above and with hills, forests and marshy places is called चेरिका.

The Aparājitapṛcchā[184] tells us that there are seventeen roads or arteries of communication in city (पुर) nine in a village (ग्राम), five in a Khetaka, three in a कूटक and two in कर्वट.

Samarāṅgaṇaūtradhāra[185] has recognised six classes of arteries of communication, namely, महारथ्या (big carriage roads), यानमार्ग (carriage roads), उपरथ्या (branch carriage roads), रथ्या (ordinary carriage roads), घण्टामार्ग (Chief road across a village highway) and राजमार्ग (city roads and highways).

The above work testifies to the good knowledge of political geography and enumerates sixteen types of geopolitical areas— 1. बालिशस्वामिनी (prosperous and well-populated region) 2. भोग्या (flourishing country) ; 3. सीतागोचररक्षिणी (areas abounding in rivers and mountains) ; 4. अपाश्रयवती (uncongenial region) ; 5 कान्ता (natural beauty spots and tourists centres) ; 6. खानिनी (mining centres) ; 7. आत्मधारिणी (sparsely populated areas with very freedom loving people) ; 8. वणिक्-प्रसाधिता (trade centres) ; 9. द्रव्यवती (productive forest areas) ; 10. अमित्रघातिनी (areas with friendly neighbours or areas uncongenial to enemies) ; 11. आश्रेणी पुरुषा (areas of pacifist people) ; 12. शाक्य-सामन्ता (neutral regions) ; 13. देवमातृका (excessive rainfall areas) ; 14. धान्यशालिनी (very productive areas) ; 15. हस्तिवनोपेता (areas noted for wealth of fauna) ; and सुरक्षा (strategic areas).

184. P. 182.

185. Chapter X 7-25.

It is noteworthy that Bhoja was a versatile genius—a combination of poet, scholar, scientist and popular ruler. Apart from this he was a great geographer also. He has actually written a voluminous geographic treatise entitled as भोजप्रतिदेश-व्यवस्था which fully deserves to be called a work on geography proper, and we know that such old texts are so rarely available in India. Thus he had very clear grasp of political geography, and in this sense in the tenth century he appears in the realm of geography proper as a second Kautilya. The above sixteen divisions of geopolitical areas evince that he had tried to be more concise and clearcut at least in a limited sphere, which the demand of chronological evolution so necessarily entailed upon him. It is a different thing that in totality he might not have excelled his predecessor (Kautilya).

Brahmanic Treatises on Geography Proper

It must be conceded beyond doubt that in ancient India there was a definite tradition of writing treatises on geography proper and such treatises do exist, though they are rare.[186] Colonel Wilford knew seven such works and possessed a few ones. Five of those mentioned belong to the Brahmanic class and period under survey.They are[187] 1. विक्रमप्रतिदेश-व्यवस्था 2. मुञ्जप्रतिदेशव्यवस्था 3. भोजप्रतिदेशव्यवस्था 4. भुवनसागर of Bukkarai and 5. विक्रम-सागर. From the description of Wilford, it appears that these works were on general and regional geography and discussed the geography of various countries.

Vikramapratideśavyavasthā is attributed to the monarch Vikramāditya. Thus it might have been composed near

186. On ancient geography of India by F. Wilford, Asiatic Researches Vol. XIV. p. 374, vide Wilford's article. Ibid., Vol. VIII, p. 268.

187. Asiatic Research Vol. VIII, p. 268. The present author had tried to procure these or to know more about them, but all his attempts proved abortive.

about the beginning of the Christian era, though Wilford believes that it belongs to the fifth century A. D. perhaps it contained eighteen or twenty thousand slokas verses. Muñja-pratideśavyavasthā was written or redacted by Muñja (uncle of the celebrated king Bhoja) in the ninth century. Wilford says that the latter is mainly the revised and enlarged edition of the former. Bhojapratideśavyavasthā is the work of the same class composed or improved by King Bhoja in 1000 A. D. The above five works were quite current and esteemed in Gujerata and south during Wilford's sojourn in India.

Kālidāsa

From Kālidāsa we learn that near about his era India was connected with various foreign countries through international Trunk Roads. Raghu in his military conquest had followed one of these routes "पारसीकांस्ततो जेतु प्रतस्थे स्थलवर्त्मना"[188], and reached Persia and thence proceeded to further west to some country north west of the former, the inhabitants of which have been designated as यवन and यवनी by Kālidāsa.

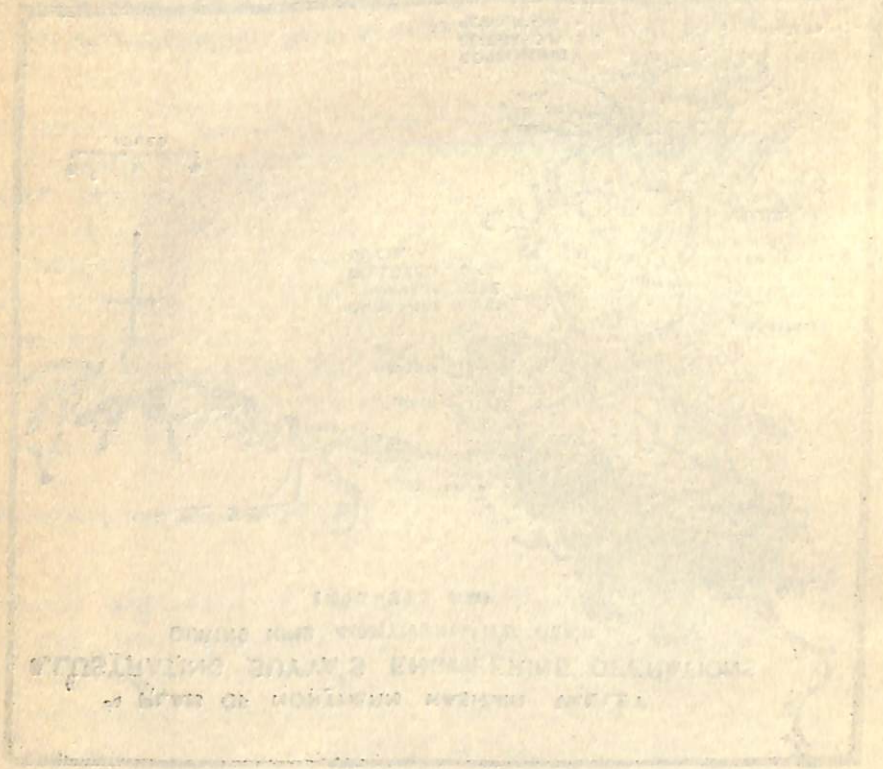
The poet refers to horses of वनायु country. We have seen above that he has very familiarly alluded to the countries west of Persia, it is almost certain that he must have been acquainted with Arabia also. If, therefore, वनायु is identified with Arabia, there should appear no geographical or historical inconsistency. N. C. Das has also identified वनायु with Arabia.[189]

The poet was fully acquainted with colonisation and its geopolitic implication. He has clearly said that it is a means of relieving population pressure in highly congested area.[190]

188. Raghuvanśa 4.60.

189. "A note on Ancient geography.....Rāmāyana" by N. C. Das, p. 5.

190. Raghuvanśa, 15.29 "स्वर्गमिष्यन्दवमनं कृत्वेवोपनिवेशिता" ।



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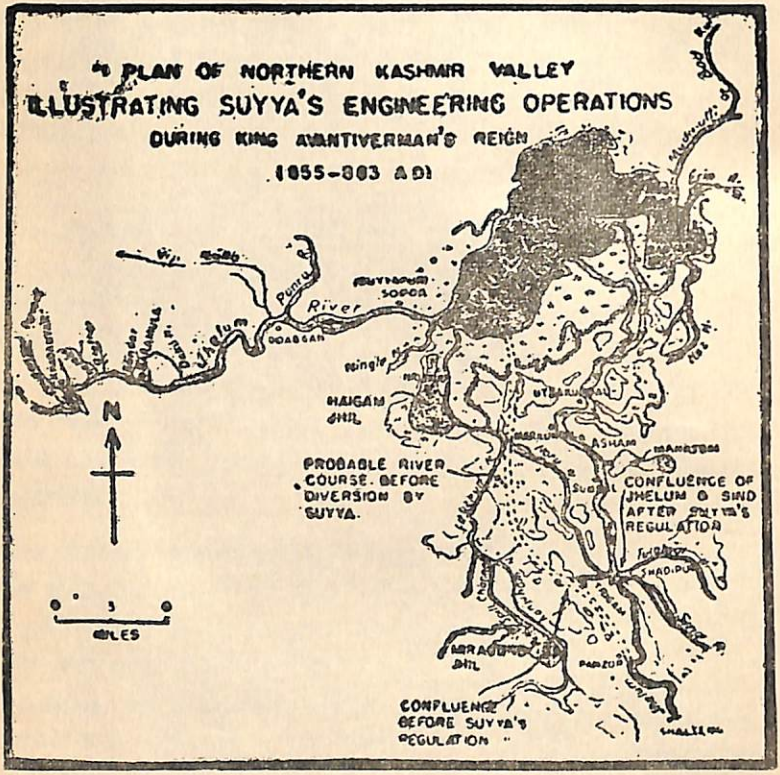

Fig. 15
Multipurpose Project in Ancient India.

For emigration and colonisation two technical terms "अभिष्यन्दवमन and उपनिवेशिता" have been used.

Kalhaṇa (कल्हण)

King Avantivarman (855-883 A. D.) and his engineer Suyya must have been a great aid to the contemporary geography as is indicated by Kalhaṇa.[191] These two initiated the "Multipurpose Project System" (Cf fig 15.) for the first time in real modern sense in ancient India. Suyya, the great engineer, effected the systematic regulation of the course of the Vitastā (modern Jhelum), controlled flood, increased the facilities for irrigation[192] and accomplished economic prosperity.

It is further noteworthy that Kalhaṇa uses the Vedic technical term कुल्या for cannals.[193]

Tāntric Literature

In discussing general and regional geography, a reference must be made to the Tantras, as they form a distinct class of literature. Being encylopeadic in character they also throw some light on various geographic topics. One of the oldest texts Tantrāloka has got a separate geographic chapter (8) entitled as देशाध्वप्रकाशन. But it contains nothing particular and is almost entirely based on the Purāṇas in dwelling on seven continents, seven seas, Maryādā Parvatas and Viṣkambhaparvatas.

Though the date of Tārātantra and Gālavatantra has not been accurately determined, still since they have got some valuable material, a cursory reference to them is being made here on the supposition that they approximately belong to the period under investigation. These texts embody useful

191. Kalhaṇa's Rājataraṅginī, Eng. Trans. by M. A. Stein, Preface, p. 98.
192. Ibid., p. 98. Vide "अतीत का अभिनवालोक" by Maya Prasad Tripathi रश्मि ५
193. Ibid. First Book, I, 97. p. 17.

geographic enumeration of compact and systematic reference to a large number of countries.[194]

Vaidyaka Works

This class of literature furnishes plenty of information on medico-geography, human geography and industrial and economic geography.

The Suśruta Sanhitā (200 B. C.) has discussed the medico-geographic properties of water of various geographic areas—subterranean region, rivers with different sources and falling in western and eastern oceans, and of tanks, mountain streams and falls, sandy tracts, small depressions, oceans and plains and areas.[195] One example would be sufficient to illustrate the methodology. "Waters of swift-flowing and limpid rivers are light, or have light qualities (लघुगुण). Those of rivers full of vegetation (Saivāla), and sluggish and turbid have the qualities of being heavy. Waters of rivers of desert region are bitter, briny, astringent, digestible, some times a little fresh and energising."[196]

Two similar chapters (Sūtrasthāna 6 and 27) occur in the Carakasanhitā (200-300 B. C.) also. The chapter 27 is almost identical in contents with the above.

The sixth deals with seasonal changes, accompanying climatic variations, their effect on human body, its functions, activities and efficiency, dietic adjustment, precautions and mode of living. Some of these assertions very well resemble those contained in the treatise[197] of E. Huntington, a modern authority on Human Geography.

The Rasaratnasamuccaya (500 A. D.) by Vagbhattācārya is a work which provides quite accurate and satisfactory

194. "On the Ancient Geography of India" by Wilford, Asiatic Researches, Vol. XIV, p. 379.
195. Sutrasthāna, Chapter 45, paras 20-38.
196. Ibid., Chapter 45, paras 22-23.
197. Principles of Human Geography by E. Huntington.

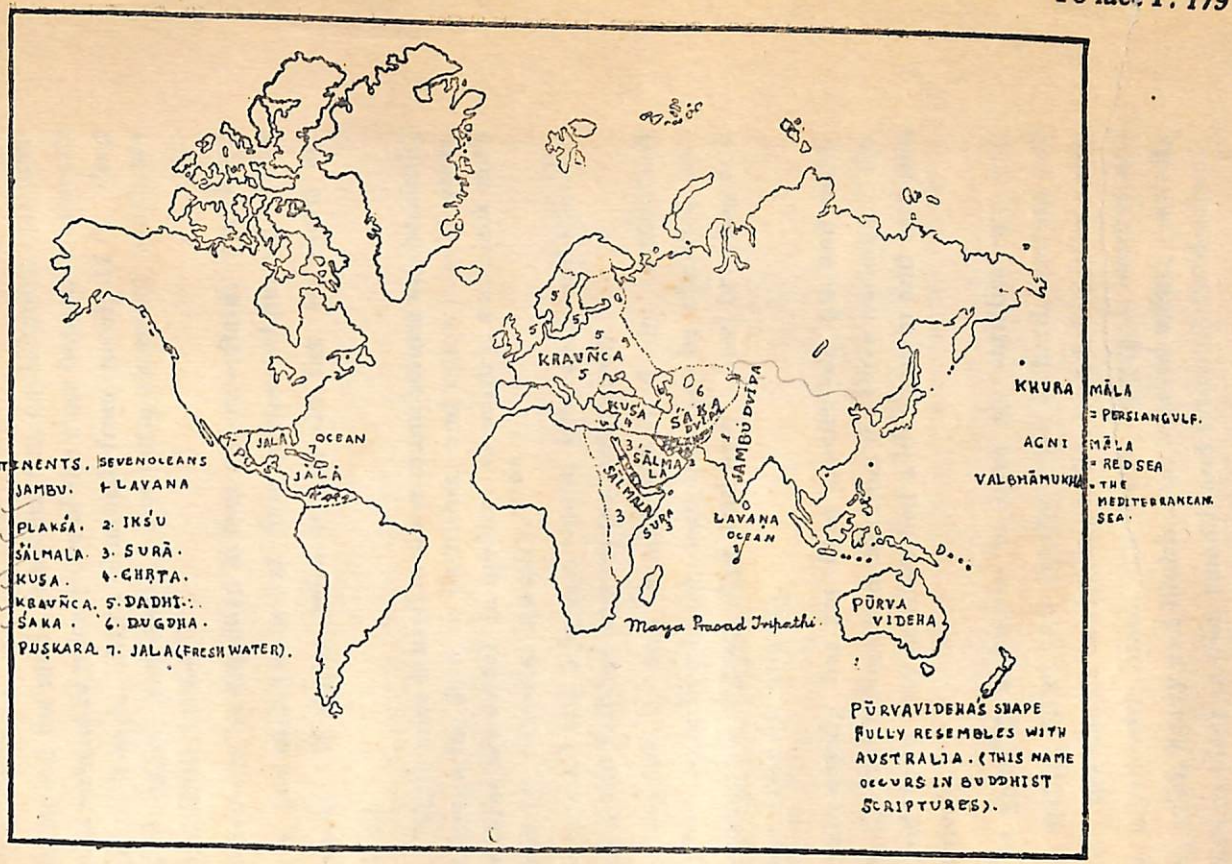

Fig. 5

Probable identification of seven continents and seven oceans.

information on Economic Geography-cum-Economic Geology cum-Minerology.

Regarding the mode of occurrence, exploitation, classification and colours of mica (one of the most important minerals of India), it says, "Mica obtained from nearly 12 ft. deep mines is heavy and useful. But mica, sheets of which are thin is of little utility."

"Mica can be classified in four genera—पीनाक, नाग, मण्डूक and वज्र, and each genus has four species—white, red, yellow and black. If पीनाक mica is put in fire, its sheets are separated.

"...White mica is used in silver manufactures or chemicals; red in preparing dyes, or barnishes; and yellow in gold works. These three are useful in medical chemistry, and black mica is utilised in chemical industry."[198]

Chapters 3 and 5 furnish similar geographic and scientific details about sulphur and copper respectively.

In chapter 5, iron is also discussed in considerable detail,[199] according to the text, iron can be classified into three categories लोहमुण्ड, तीक्ष्ण and कान्त. Steel or अयस्कान्त is another name for कान्तलौह.

Again मुण्डलौह has got three species—मृदु, कुण्ठ and कण्डार. Then the text defines and describes the three varieties. The first and third may be identified with wrought and cast iron respectively.

The तीक्ष्णलौह is known to have six varieties—खर, सार, हृन्नाल, तारावट्ट, वाजिर and काललोह. खर is hard, lustrous and brittle. सार can be easily bent and is found in yellow rocks. हृन्नाल is yellowish black and hard. तारावट्ट is lustrous and pliant, solid, heavy and bluish iron is called वाजिर. काललौह is bluish or black in hue, smooth and extremely hard-edged.

198. Chapter. 2, 3-4-5, 9-10.
199. 5. 71—94.

There are five varieties of कान्तलौह—भ्रामक, चुम्बक, कर्षक, द्रावक and रोमकान्त. Each of these has further got several species. Then their properties are discussed, but here details are scarcely based on scientific knowledge.

In the some continuation several other minerals are discussed from geographical, geological and chemical point of view.

Rasārṇava (700—800 A. D.) in another work belonging to the above category. It has also discussed the geographical and minerological aspects of various metals and minerals, for example, mica, sulphur, iron, gold, silver, copper, lead and others. It generally concords with Rasaratnasamuccaya and is more concise in account.

The Carakasanhitā[200] has recognised five types of salt—1. the सौवर्चल salt ; 2. the rock salt सैन्धव ; 3. the red granular salt known as विड ; 4. the efflorescent salt obtained from ground (alkaline soil or रेह) ; and 5. ocean salt सामुद्र.

Treatises on Gems and Minerology Proper

In surveying Vṛhatsanhitā we have seen that this science was highly developed in ancient India and there had been several authorities and tomes on the subject prior to Varāhamihira. Regarding it "The classical age"[201] says, "Indeed this art was so highly developed as to give rise to a branch of science called Ratnaparīkṣā (examination of jewels) which was sufficiently old to be included among the sixty four subsidiary branches of knowledge in Vātsyāyanas Kāmasūtra and recognised as a part of training of merchants' sons in the Divyāvadāna."

Talking about the extant texts on this science, Keith[202] has specifically mentioned the three the अगस्तिमत, the रत्नपरीक्षा of Buddhabhatta and the नवरत्नपरीक्षा of Narain Pandit and other "minor texts." He is uncertain about the

200. Sūtrasthāna. Chapter. I. Verse 88.
201. Edited by R. C. Majumdar, p. 588.
202. A History of Sanskrit Literature, p. 465.

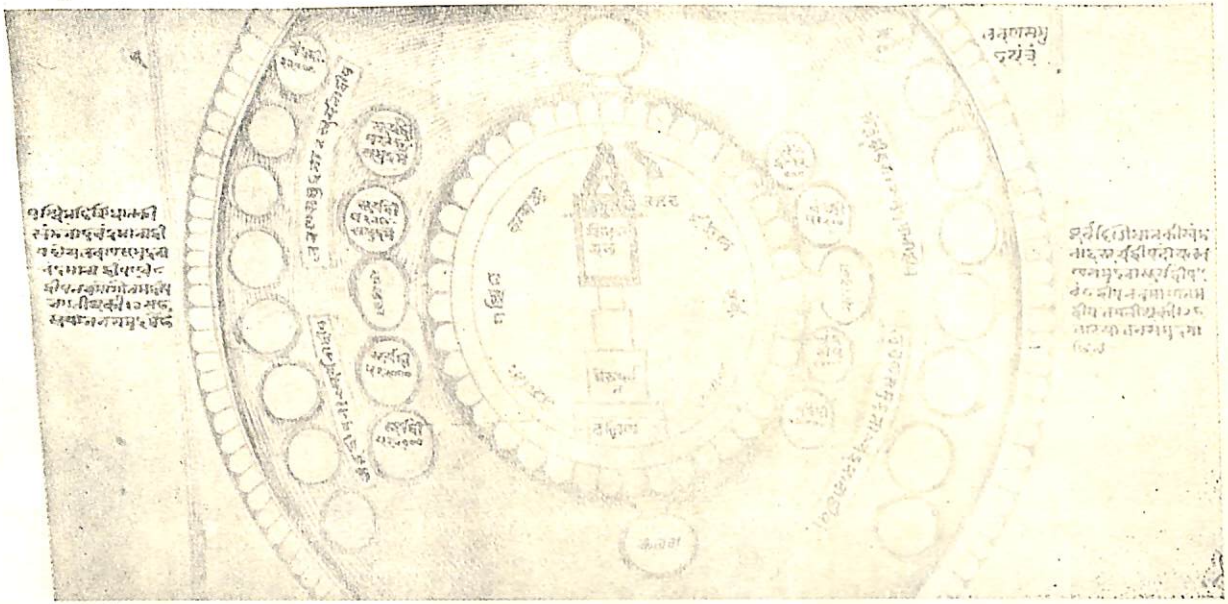

Fig. 17

Lavaṇa ocean, Jambūdvīpa and other Dvīpas according to Jainas (oriented towards the north). [After Laghukṣetrasamāsa in Vārāṇaseya Sanskṛta Viśvavidyālaya, Varanasi].

Since the Laghukṣetrasamāsa is based on the Vṛhatkṣetrasamāsa, this map must trace its origin from the latter work, and thus its inception may belong to 700 A. D. (the date of the latter treatise) or even to an earlier era.

date of three important works and thinks them to be of "late date." The term "late date" however, actually points to nothing. But Buddhabhatta is quoted by Mallinatha (C. 1400 A. D.) in his commentary or verse 1.24 of the Kumārasambhavam. Hence the former must have flourished before 1400 A. D. So he may belong to the period under discussion. The Agastimata appears to be still older than Buddhabhatta. That also, therefore, may be presumed to have been composed much before 1200 A. D. But nothing can be surmised about Narayana Pandit.[203]

Jain Texts

In broader outlines general and regional geography of the Jainas resembles that of the Brāhmaṇic system or the Purāṇas. The form, spirit and methodology of both the schools are also the same. Both abound in legendary and imaginary materials. Confused accounts are also interspersed in them in profuse quantity. But in detailed structure the Jain geography is in much variance with the Brāhmaṇic system. Comparatively the former is much marked by greater confusion than the latter. In dealing with the geography of Jambudvīpa and India, the Jainas have attempted to be a little sober and accurate, but in this respect also they occupy an inferior position to their counterpart, namely, the Brāhmaṇas. In the realm of geography of Jambudvīpa they appear to be much ahead to the Brāhmaṇas in furnishing fabulous and preposterous information. Their treatment of geography of India is inadequate and sketchy.

World Geography (Cf fig. 16, 17).

In Jain geography there is an enumeration of 32 important dvīpas (island) and oceans. The sixteen dvīpas are the inner ones and the other sixteen are known as the outer

203. For a succinct account of "Ancient Indian Minerology" Cf. Chapter IV of the "Positive Background of Hindu Sociology" by B. K. Sarkar.

ones, with each sixteen go the sixteen oceans, which encompass them alternatively. The innermost island or continent is Jambudvīpa and the first continent of the outer-most ones is स्वयम्भूरमण. The area of each pair of islands and oceans is double of the preceding one.

The first most important set of continents is comprised of Jambudvīpa, Dhātakīkhaṇḍa, Puṣkaravara, Varuṇavara, Kṣīravara, Ghṛtavara, Ikṣuvara and Nandīśwaravara (or merely Nandīswara) which are concentric circles and engirdled by Lavaṇoda, Kāloda, Puṣkaroda, Varuṇoda, Kṣīroda, Ghṛtoda, Ikṣūda and Nandīśwaroda oceans respectively.[203a]

The other set of inner dvīpas is comprised of Aruṇavara, Aruṇabhāsa, Kuṇḍalavara, Śaṅkhavara, Rucakavara, Bhujagavara, Kuśavara and Krauñcavara islands which are encompassed by the seas of the same names respectively.[204]

Similarly the outermost or last sixteen dvīpas are counted from स्वयम्भूरमण and end at Manaḥśila dvīpa and are girt by the seas of the same name.[205]

Apart from these there is a large number of continents or islands and seas in this तिर्यक्लोक or world. This number is further specified to be $2\frac{1}{2}$ Sagara (a Jain denomination which denotes a particular number which is extremely large).[206] The Jain texts have enumerated a big number of rivers, mountains and lakes of the world.

Then there is another system or school of Jain geographers which emphasises or recognises only two and half dvīpas or

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203a. Sūryaprajñapti, Prābhṛta 19, Sūtra 100 and 103 ; Tatvārthādhigama III. 7-8 and their commentaries ; Tiloyapaṇṇatti V. 11 to 27.

204. Sūryaprajñapti, Prābhṛta 19, Sūtra 103; Tiloyapaṇṇatti V. 17.27.

205. Tiloyapaṇṇattī V. 22.26.

206. Akalaṅkadeva Tīkā of Tatvārtha III. 7. The Tiloyapaṇṇattī slightly differs from it. Cf. V. 27.

continents which go to make the world. The first two dvīpas are Jambu and Dhātakikhaṇḍa. The former is situated at the centre and the two are separated by the Lavaṇoda ocean. The three are surrounded by another ocean named Kāloda. In the last ocean are found several dvīpas which are designated as Antima or Vāhyadvīpas islands situated at the extremity. The five chapters of the Vṛhatkṣetrasamāsa (C. 650 A. D.) are christened according to this conception.[207] Several of old Jain maps of the world have been drawn according to this idea. Thus we find that in the above two schools of Jain geography much confusion prevails.

Concentric circles of islands, continents and oceans encompassing them are the ideas of Brāhmaṇic tradition. Several of the names are also common to both.

Jambudvīpa—The geography of Jambudvīpa is described in various Jain texts.[208] These give the same dimensions of the continent as the Purāṇas, namely one lakh yojanas. The Sūryaprajñapti says[208a] that it is of the shape of a wheel divided into five parts (जम्बूद्वीप: पञ्चचक्रभाग-संस्थित:). The Jambudvīpaprajñapti[209] divides the continents into seven Varṣas (also known as Kṣetras): 1. Bhārata; 2. Airāvata; 3. Haimavat ; 4. Hiraṇyavat ; 5. Harivarṣa ; 6. Ramyaka; and 7. Mahāvideha. There are six varṣaparvatas of the continent. 1. Himavān ; 2. Mahāhimavān ; 3. Niṣadha ; 4. Nīla ; 5. Rukma and Śikhara.[210] Rivers, mountains,

207. Vide Tiloyapaṇṇattī IV. 2.

208. Jambudvīpaprajñapti ; Tattvārtha III. 9 and its Tīkā ; Vṛhatkṣetrasamāsa "Jambudvīpādhikāra" ; Tiloyapaṇṇattī Mahādhikāra 5, Lokavibhāga Chapter I ; and others.

208a. Prābhṛta 3, leaf 63.

209. Vakṣaskara 6, leaf 487. In the same work Vakṣaskara 4, leaf 336, there is another list of Varṣas—Videha, Mahāvideha, Pūrvavideha, Aparavideha, Devakuru and Uttarakuru.

210. Tattvārtha III. 11 and other texts.

lakes, regions, forests and inhabitants are also discussed, but most of the account is unscientific.

India or Bhārata—As already said, Bhārata was recognised by the Jainas also as a Varṣa of Jambu. In the commentary of aphorism 10 of the Chapter III (Tattvārtha) Akalaṅkadeva says, "Bhārata Kṣetra is bordered by Himavān mountain on one side, and by oceans on three sides. The Gangā-Sindhu rivers and the Vijayandhara mountain divide it into six regions." This country is 1/190 of the dimension of Jambu-dvīpa.[211] Thus if one lakh (dimension of Jambu) were a linear measure, the length or breadth of Bhārata comes to be $526\frac{6}{19}$ yojanas (nearly 2500 miles) which may be said to be correct.

In the Jambudvīpaprajñapti the shape of Bhārata is said to be that of a cot in the north and a bow (literally back of a bow) in the south. East to west is length and north to south is breadth.[212] River names and some other geographic details are also furnished.[213]

Jain Treatises on Geography Proper

The most outstanding contribution of the Jainas in the realm of geography in India is that they have composed largest number of treatises on the science of Geography, some of which belong to era even prior to Christ. These texts have dwelt on almost all the branches which are known to modern geography. Of course, matter concerning general and regional geography predominates in them.[214]

Miscellany

In the commentary of Prajñāpanā[215] Haribhadrasūri (705-777 A. D.) describes twelve types of vegetation. 1.

211. Tattvārtha III. 32 ; Tiloyapaṇṇattī IV. 105.
212. Vakṣaskara I, leaf 335.
213. Tiloyapaṇṇattī IV. 94-100-195-196-252.
214. Cf. Envoi and Bibliography of my present thesis "Development of Geographic Knowledge in ancient India" and "भारतीय भूगोलशास्त्रमें जैनों का योग" मायाप्रसाद त्रिपाठी नागरी प्रचारिणी पत्रिका, वर्ष ६५, अंक ३ ।
215. Chapter I, Sūtra 19, leaf 30.

trees : 2. गुच्छ (bushes like वृत्ताकी); 3. गुल्म (shrub); 4. लता (creepers); 5. वल्ली (long creeper growing on the ground); 6. पर्वग (like sugarcane); 7. तृण (like Kusa-Poa Cynosuroides); 8. वलय (plantain and the like) 9. हरित (rice and the like); 10. ओषधि (fruits and mountainous flora); 11. जलरुह (water vegetation) and 12. कुहणा (growing underground).

A reference in Samaraiccakahā informs that coal production and coal trade were in flourishing state.[216]

In the Tiloyapaṇṇattī there occurs an allusion to मयण wax or candle.[217] Had those Indians known to develop such an industry ? It is proved beyond doubt that kerosene oil was imported in India from the middle east near about 300 A. D.[218] In this connection it must be remembered that wax obtained from bees was called मधूल or मधूक.

Several town plans mentioned in the Jambudvīpaprajñapti[219] (नन्द्यावर्त, वर्धमान, स्वस्तिक and the like) and the Tiloyapaṇṇattī[220] (खेट, कर्वट, पट्टन etc.) prove that the Jainas had the same concept of urban geography as the contemporary Hindus. But Aṅgavijjā (400 A. D.) appears to make a genuine improvement on the traditional urban geography. In its chapter 29 it gives sixty four classes of cities—राजधानी (metropolis); शाखानगर (satellite); पर्वतनगर (mountain city) आराम बहुल (city of parks); पविट्टनगर (densely populated); and विस्तीर्ण नगर (spacious city) and the like. Here their permanent or temporary inhabitation, heavy or scanty

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216. Biblothica Indica series, p. 50 (इङ्गालकम्भ) Vide my article in the Āj of 13.10.63; and my work "अतीत का अभिनवालोक," भाग १, रश्मि १.
217. II. 32.
218. आर्यमञ्जुश्रीमूलकल्प, पटलविसर 55, p. 686. In Sanskrit Lexicons candlestick has been called "दीपपादप".
219. Vakṣaskara 3, leaf 200,
220. As described by Tiloyapaṇṇattī IV. 1398-1400.

rainfall, different sizes aud shapes, orientation, boundary of forests, gardens, hills are also mentioned. Emphasis is laid on their climatic condition, prosperity and adversity. The same source informs us of the developed state of naval architecture (उदकवार्धकि).[221]

There was a tradition among the Jainas of जनपदपरीक्षा[222] (touring and investigation of countries and areas) which did much to develop the cause of field work and regional geography.

Buddhists Scriptures

World Geography—Almost all the Buddhist texts inform that there are four big continents, but according to the आर्यमञ्जुश्रीमूलकल्प[223] there are seven continents; perhaps it was due to Brāhmaṇic and Paurāṇic influence. From the preceding pages it is already clear that the Brāhmaṇic system of geography had exercised some definite influence on the Buddhists. Abhidharmakośa[224] gives the names of four Mahādvīpas thus—Jambu, Pūrva-videha, Avaragodānīya and Uttarakuru. There are eight Antaradvīpas situated in the intermediary space between the above four—Cāmara and Avaracāmara near Jambu; Deha and Videha near Pūrva-videha; Kuru and Kaurava near Uttarakuru and Śāṭha and Uttaramantri near Avaragodānīya. The same chapter of Abhidharmkośa gives the shape and dimensions of the various Mahādvīpas. The Antaradvīpas are known to have the same shapes and half the sizes of the major continents in whose vicinity they lie.[225] (Cf. fig. 18, 19).

The oldest reference to the Mahādvīpas are found in the Lokaprajñapti, then in the Pañcabudha[226], Dipi[227]

221. Chap. 28, p. 160.
222. Sārthavāha, p. 164.
223. Patalavisara 55, p. 176. "सप्तद्वीपाधिपो वशमागच्छति"
224. Kośasthāna III (with commentary of Yaśomitra).
225. Encyclopaedia of Religion and ethics, Vol. IV p. 133.
226. Fauseboll, Jātaka No. 55.
227. Ibid., No. 426.

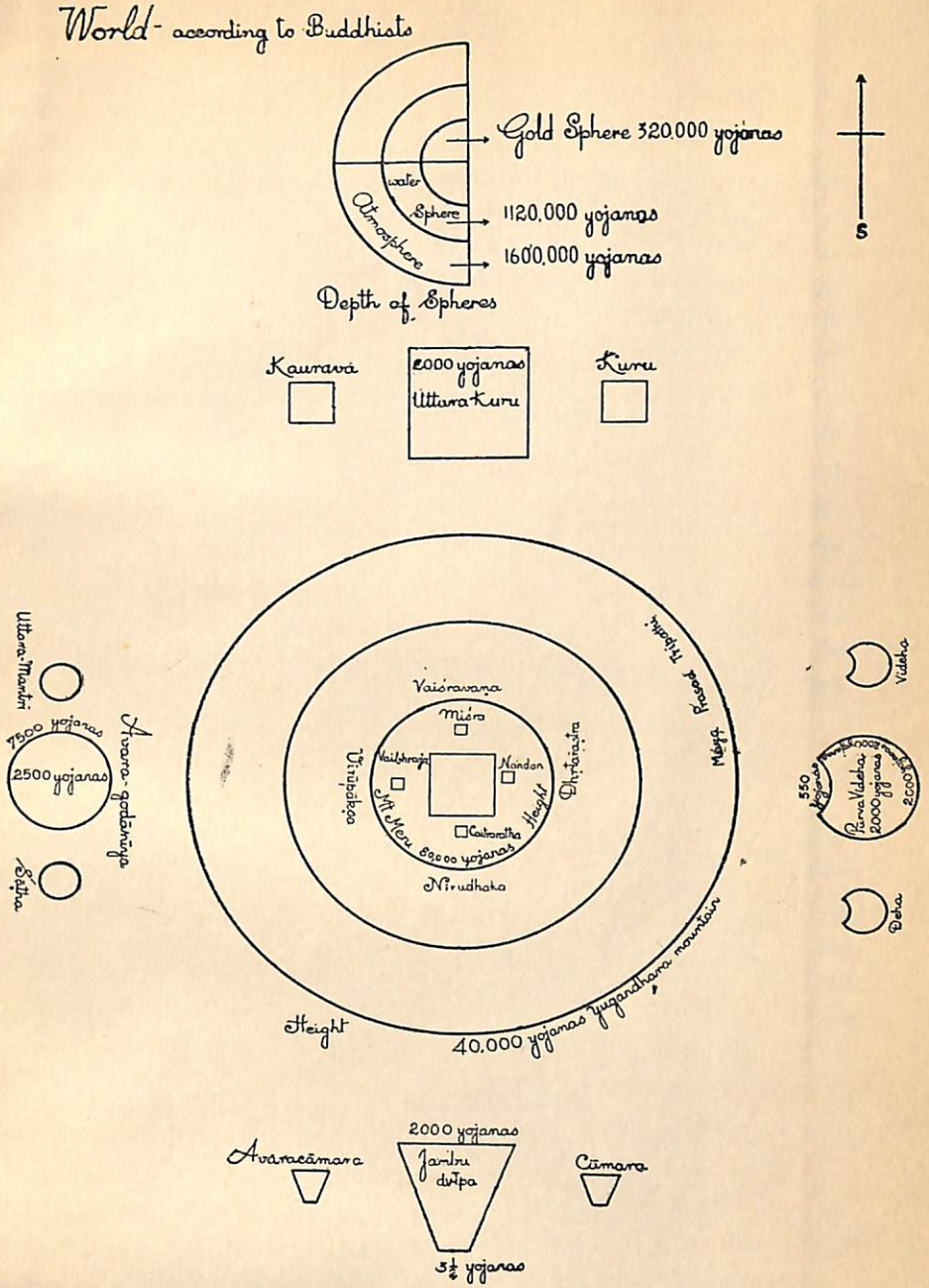
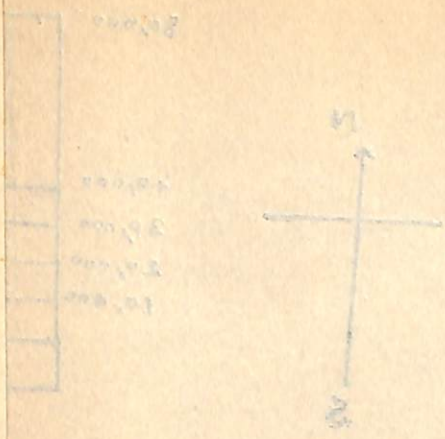


Fig. 18

World according to Buddhists. Four world continents. Secondary dvīpas are similar in shape to and half the size of the main dvīpas (continents). Four main continents and eight secondary dvīpas in all.



Kuṇāla[228] and various other Jātakas. The Lalitavistara says[229] that there is a large number of other islands also.

From the Nimijātaka[230] we learn that there are eight world mountains. According to this the remaining seven stretch about the Meru. They bear the names: 1. Sudarśana; 2. Khadiraka; 3. Īṣādhara; 4. Yugandhara; 5. Nimidhara; 6. Vinataka; 7. Aśvakarṇa. In the Abhidharmakośa[231] we read Cakravāla instead of Aśvakarṇa. The Divyāvadāna[232] names some of the mountains thus—Śankhanābha, Sankhanābhi, Nīlodasa, Tarkākṣa, Nilagrīva, Vairambha, Tāmrātavī and Veṇugulma. The Chadanta Jataka[233] contains another list of seven mountains 1. Cullakālaparvata; 2. Mahākālaparvata; 3. Udakaparvata; 4. Candrapassaparvata, 5. Sūrya passaparvata; 6. Mahiparvata; 7. Suvarṇaparvata. But it is very difficult now to identify the above mountains. In connection with the Buddhist geography also, it must not be forgotten that this also abounds in legendary and imaginary material.

India

The Dīghanikāya[234] reveals that the contemporary Indians knew very accurately the shape of their country. The text assigns it a shape of a cart (शकट) which is really quite correct, specially when we take into account such an old period. Various data from Buddhist works go to prove beyond doubt that the Buddhists were fully acquainted with the geography of whole India from the Himalayas to Ceylon.

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228. Ibid. No. 536.
229. Lefman, p. 95.
230. Fauseboll, Jātaka No. 541. Cowel, p. 66.
231. Kośasthāna. III.
232. Avadāna 8, p. 102.
233. Fauseboll Jātaka No. 514.
234 Vide "भारत की मौलिक एकता" by V. S. Agrawal, Chapter 9. p. 163.

Different Buddhist sources indicate with positivity that internal navigation was in a flourishing state. [235] Trade and commerce along sea shores (coastal shipping) and in mid-ocean both were highly advanced. [236]

Lines of communication were much developed. The Mahāniddesa mentions several types of such arteries—Jannu-patha, Ajapatha, Mendapatha, Śankupatha, Chattapatha, Vanśapatha, Śakunapatha, Mūṣikapatha, Daripath and the like. Large cart and carriage roads wove a net around the country.

The Āryamañjuśrīmūlakalpa[237] show that kerosene oil was being imported in the country prior to 300 A. D. By that time seri-culture also made commendable strides in India.[238]

Two references of the Divyāvadāna evince that human and animal census had come to occupy a place in the economy of the country and were quite current. 'सर्वजम्बूद्वीपान् सत्वान् गणयेयम् "and" "सर्वजम्बूद्वीपान् मनुष्यान् गणयन्ति".[239] For this purpose villages and towns both were paid equal attention. Organi-sation of the Mauryan Government fully corroborates this. The Dīpavanśa shows[240] that coastal Indians knew the construction of dykes (वणक) in the ocean like the inhabi-tants of Netherlands in modern times. Chapter XVII of the same text gives very good geographic details of Laṅkā, and is illustrative of the concept of true methodology of geography.

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235. Fauseboll, Jātaka No. 543, Cowel Vol. VI, p 105 and other Jātakas.
236. Samudra Vaṇika Jātaka. Fausebool. No. 466. Mahā-janak Jātaka No. 539, and others.
237. Patalavisara 55, p. 686. Here Kerosene oil is called तुरुष्कतैल.
238. Laṅkāvatārasūtra, p. 141. The same as we have read in the Mahābhārata (XII. 330.29).
239. p. 292-3.
240. XX. 35. p. 212.

Questions of the Chapter II of the Laṅkāvatārasūtra unmistakably evidence that the geographic enquiry had attained quite high and refined standard. Various Buddhist scriptures have designated the people well-versed in this science as लोकाख्यायिका.[241] It implied "Geography" also.

The Buddhists also have a special treatise on geography proper, it is known as लोकप्रज्ञप्ति, and forms a part of प्रज्ञप्तिशास्त्र, the second treatise of the Abhidharmaśāstra of the Sarvāstivādin school. The Lokaprajñapti contained nearly 200 pages and was a voluminous treatise.[242] Its subject matter is detailed thus—

"भूगति-जम्बूद्वीप-षण्महादेश-यक्ष-राजगिरि-हस्ति-मेरु-परिगत-चतुर्द्वीप-कालाकारपरिमाणाकाशसुदर्शनेन्द्रासुरयुद्ध-चन्द्रार्क-गत्यहोरात्रविभागजात्यायुर्नरक लघुसंवर्तनित्रय-महासंवर्तनित्रयाणि"[243]

According to Poussin[244] the authorship of the लोकप्रज्ञप्ति must be attributed to that of प्रज्ञप्तिशास्त्र and since Rāhula[245] says that the latter was written by Maudgalāyana, naturally लोकप्रज्ञप्ति, forming a section of the प्रज्ञप्तिशास्त्र must have been written by the same person. Hence the book was composed or compiled somewhere in the sixth century B. C.

General Features of Indian Exploration and Colonisation

In Japan there is found a small number of nordic Aryan population. Dr. K. Motawani has attempted to show

241. Milindapañho (Eng. Trans.) IV. 6. 63 ; Divyāvadāna लोकाख्यायिकायां कुशलाः, p. 304 ; Mahāniddesa, p. 367, 374.
242. भूमिका of Abhidharmakośa commented by Rāhula Sāṅkṛtyāyana.
243. भूमिका of Abhidharmakośa commented by Rāhula Sāṅkṛtyāyana.
244. Encyclopædia of Religion and Ethics, Vol. IV, "Buddhist Cosmogony."
245. भूमिका of Abhidharmakośa commmented by Rāhul.

that these are Indian Aryans who migrated to Japan several millennia B. C. Ainus is merely a corrupt form of Aryans.[246] In the Ṛgveda and Sāmaveda[247] we have got a word "Anu" denoting a tribe. From this evidence also the present Ainus of Japan appear to be descendents of the colonising Anus of India, because in the two there is definite ethnological similarity also. The same scholar further maintains that Indians had migrated to Egypt at least 3400 B. C. and explored and mapped the country.[248] Cunnigham also purports to say that detailed exploration of Egypt is due to the ancient Indians, not to Ptolemy (the great geographer) who flourished much later.[249]

Dr. Motawani believes that Indian Aryan people and their influence had migrated to Baltic countries, Australia and New Zealand. He has tried to trace the influence of Mānavadharma Śāstra on these lands much before Christ.[250]

Putting reliance on various archaeological evidences (for example Asokan rock edict of Kalsi) and numerous Jātakas, it can be said with certainty that by the 3rd or 4th century B. C. Indians were fully acquainted with and travelled to the mediterranean region, Northeast Africa, some portions of the Pacific and Siberia in the north. Some scholars opine that by the end of the Buddhist period, that is, near about the beginning of Christian era, the Buddhists had established contact with Mexico, Central and South America. Discussing the archaeological relics and other evidences, and antiquarian accounts, they have endeavoured to establish that ancient Mexican, Javan and Cambodian civilizations owe their origin to the same source. In this connection "Hindu

246. "Mānavadharmaśāstra" K. Motawani, p. 233 and preceding ones.
247. Ṛgveda I. 108. 8. and others ; Sāmaveda IX. 13, p. 136.
248. Mānavadharmaśāstra, p. 271.
249. Ancient Geography—Introduction.
250. Mānavadharmaśāstra, p. 237, 305.

America" by Chaman Lal is interesting and worthnotice.[251] Is the name Guatimala of a town of Central America is corruption of Sanskrit name Gautamālaya—an abode or town of Gautam (the Buddha) ?

Colonisation follows in the train of trade. In the Buddhist period Indian maritime trade was in its heyday. (Cf. fig.20,21). Ports were highly developed. Accounts of journey and trade by very big Sārthavāha (Caravans) prove that land trade was also in a flourishing state in the Buddhist period. Western Asia, Central Asia, China and other countries were linked together commercially. Entrepôt trade was at its zenith. Sākala was the chief centre of such trade activities. Here bales of commodities were opened (पुटभेदन was performed).[252] National and international commercial highways ramified in all quarters.[253] They must have given rise to considerable exploration and colonisation. According to a recent news paper report, a two-thousand years old colony of Indians has been discovered in the south of Caspian Sea in Russian Territory near Baku.

Indian Buddhist missionaries, for example, Dharmaratna, Kaśyapamataṅga,[254] Kumara Jīva (C. 400 A. D.) Jñana-bhadra, Dharmakṣema, Bodhidharma and others, [255] must have had contributed immensely to the cause of Indian explorations by their travel and foreign contacts.

Indians never fought shy of travelling in unknown foreign lands strewn with extraordinary hazards and risks to life. For their trade and economic activities they intrepidly and successfully attacked all sorts of difficulties. A graphic account

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251. Vide "A note on ancient geography of Asia...Rāmāyaṇa" N. C. Das, p. 58 and in "Asiatic Researches, Vol. XI, Wilford, p. 105.
252. Milindapañho, Vol. I, I. 2.
253. Cf. सार्थवाह by Dr. Moticandra.
254. The Age of Imperial Unity, p. 645.
255. The Classical Age, Chapter XXIII, p. 597 to 601.

of this is quoted below from the Niddesa, which depicts the story of Sānudāsa :

"Sānudāsa joins the gang of the adventurer Achera, who is preparing an expedition to the land of gold (Suvarṇa-bhūmi). They cross the sea and land at the foot of a mountain. They climb up to the top by catching hold of creepers (Vetra). This is the creeper's path (Vetrapatha). On the Plateau there is a river which changes into stone everything that falls into it. They cross it by holding on to the bamboos, which overhang the banks. This is the "bamboo patha" (Vaṅśaptha). Further on, they meet a narrow path between precipices. They light a fire with wet branches; the smoke attracts some kirātas who come and propose to sell them some goats ; the adventures get on these goats, the only animals sure-footed enough to be able to follow the narrow edge without feeling giddy. This is the goat's path (Ajapatha). The adventures do not come to the end of it without some difficulty, as another gang is approaching from the opposite direction. A struggle ensues, but Acheras troops are able to pass through after having thrown their enemies into the ravines. Sānudāsa begins to feel indignant at the fierceness of the gold seekers. Achera orders his followers to slay the goats and to put on their skins with the inside out. Huge birds will mistake these men for a heap of raw meat, come and carry them away to their aerie. It is there that the gold is ! Sānudāsa attempts to save the goat he was riding ; but his companions are pitiless. Everything takes place as Achera foretold ; but the bird which carries off Sānudāsa is attacked by another bird which attempts to steal his prey. The goat's skin bursts open and Sānudāsa falls in a tank which is in the heart of a luxurious forest. The next day he comes to a river, the banks of which are of golden sand ; nearby, there is a hermitage from which a hermit comes out."

"The above story refers to several 'paths' or ingenious means of passing through difficult territory. A few more of these paths are referred to in various early books. There is Jannupath where one has to crawl on hands or knees.

Śaṅkupatha was a difficult and laborious procedure for ascending a mountain. An iron hook, attached to a rope of skin, is thrown upon to the mountain side where gets embedded. Having climbed up the rope, the man makes a hole on hill side with a diamond-tipped iron rod and fixes a spear. Having caught hold of this, he detaches the hook and repeats the performance till the spear is again fixed up in a mountain. Then he ties the rope to spear, and having caught hold of the rope with one hand, strikes it by a hammer with the other till the spear is detached. Then he climbs up again, again fixes the spear, and repeats the process till he ascends to the top of the hill. Last comes Chattapatha, the means of coming down from a steep height. One jumps down from a precipice with an open parasol made of skin, and descends slowly to the grounds on account of the resistance of the air. In other words, it acted as a parachute."[256]

For conclusive remarks we cannot do better than to quote a few lines from the phlegmatic and sober historian, Dr. R. C. Majumdar, "The stories quoted above and numerous other Indian folktales about merchant going beyond the sea indicate that the spirit of exploration and adventure was a characteristic feature of ancient India."[257]

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256. Reproduced from The Age of Imperial Unity, Ed. by R. C. Majumder, p. 652-58.

257. Ibid., p. 653.

For more maps referred to in this chapter Cf chapter IX.

Development of Geographic Knowledge in Ancient India

CHAPTER VIII

Concepts of Ethnology and Anthropology

Ethnology
Anthropology
Marriage customs
Commingling of Races
Anthropometry
Anthropography

CHAPTER VIII

CONCEPTS OF ETHNOLOGY AND ANTHROPOLOGY

The Vedic beginning

The Ṛgveda had some conception of ethnology and anthropology also. There are described features of Indra and some other deities. Mantras I. 7. 9[1] and I.100.12 classify the inhabitants of earth in five classes. Sāyaṇa, again, finds in I.164.14 a reference to five classes of human beings. Mention and description of the Asuras and Dāsas (black-skinned, flat-nosed and evil-tongued) are too well-known and it is unnecessary to indulge in their useless repetition.

The hymn X 85 gives a very vivid and detailed account of the Aryan marriage customs, practices and the whole ceremony.

The Sāmaveda merely repeats the above information of five races in its verse IX.13. The Vājasaneyi-sanhitā refers to the order of descending superiority of the four varṇas, namely Brāhmaṇa, Kṣatriya (Rājanya), Vaiśya and Śūdra.

Macdonell and Keith in their Vedic Index[2] have collected names of sixty races of Vedic times, but it does not in any way go to point to any knowledge of ethnology and anthropology of the contemporary people.

The Rāmāyaṇa

By the time of the Rāmāyaṇa ethnological and anthropological concepts and knowledge of the Indians sufficiently crystalised. In it we come across large number of tribes indigenous and foreign both and some of the people mentioned are divine, semi-divine or mythical. The most

1. Does the word क्षिति in this verse not imply continents ?
2. pp. 590-91.

important of indigenous tribes (other than Aryans) are Rākṣasas, Vānaras, Nīṣādas, Śabaras, Nāgas, Asuras, Gṛddhras and Suparṇas. Devas, Gandharvas, Yakṣas, Cāraṇas, Siddhas, Kinnaras and Apsarās are divine or semi-divine tribes.[3] Among the foreign tribes and races Yavana, Śaka, Kāmboja, Barbara, Hārīta, Kirāta, Pahlava and Vāhlīka are specifically mentioned.

Sometimes some anthropological details are also given. The Śaka and Yavana are described as grim-visaged and of golden pigment.[4] We have a vivid account of the inhabitants of the Śvetadvīpa. "All the inhabitants that live there are gifted with strength, are effulgent like the rays of the moon, hugebodied, powerful, and have a voice deep as the muttering of clouds. They are greatly beautiful, patient and have huge arms."[5]

Rākṣasas have been depicted as of horrifying looks and black pigment. Vānaras are stated to be of various pigments —some of sun's colour, some of the moon's colour,[6] some collyrium-dark and strong,[7] others of grey colour and another section of rubiscent pigment resembling the lustrous sun,[8] and still another community of coal-dark colour.[9]

In II. 69.14 are referred to black and yellow women— the latter perhaps pointing to the Chinese people or Mongolian race.[10] Commingling of races is also described.

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3. Vide The people of the Rāmāyaṇa Age by Dr. S. N. Vyas, Journal, Oriental Research Institute, Baroda. Vol. V, No. 1.
4. I. 54. 22.
5. VII. 46, p. 1702 (Trans. M. N. Dutta) and Interpolation Chap. V (Nirnayasagar Press p. 584).
6. IV. 39. 13.
7. IV. 37. 20.
8. IV. 37. 7.
9. IV. 37. 24.
10. Prior to 209 B. C. (before the composition of the Rāmāyaṇa) India and China were definitely acquainted

Another classification of indigenous people consists of Pulindas, Śūrasenas, Prasthalas, Bharatas, Dakṣiṇa Kurus, Madras, Sindhus, Sauvīrās, Saurāṣṭras, Aṅga, Keral, Cola, Pāṇḍya and others, but it is not anthropologically so important as it is based on the regions of the country.

The Mahābhārata

The epic does not lag behind in mentioning a very large number of races. It has referred to and described more than a score of tribes and races[11] (human, divine and semi-divine), of which the most important are Deva, Gandharva, Rākṣasa,[12] Kalakeya and Pauloma,[13] Pahlava, Śaka, Śabara, Śaravaṇa, Yavana,[14] Siṃhala, Barbara, Cīna, Hūṇa, Mleccha, Civāka,[15] Anu,[16] Romaka,[17] Aśmaka (Afaghans),[18] Pārasīka,[19] Khāsīra[20] (Khurāsani) and Magas.[21] Anus have been said to be the descendants of Yayāti and Śarmiṣṭhā. Verse I. 85.34 informs us that sons of Turvasu are the Yavanas, those of Druhyu are the Bhojas, and those of Anu are the Mlecchas.

Chapters 8, 9 and 10 of the Bhīṣmaparva are strewn with ethnological information. In a certain context a few verses[22]

with each other. "The earliest mention of China in Indian literature may go back to the last years of the Imperial Ts'in dynasty (209 B. C.)." p. 766 in "A Comprehensive History of India" Edited by Prof. K. A. Nilkantaśāstrī, Vol. II.

11. I. 17. 5-6.
12. I. 1. 106.
13. I. 1. 162.
14. I. 177. 35.
15. I. 177. 36-37.
16. I. 75. 35.
17. II. 51. 31.
18. VI. 9. 44.
19. VI. 9. 66.
20. VI. 9. 68.
21. VI. 12. 36.
22. VI. VI. 34-37.

give the pigment of men to be golden and that of women of lotus, of exceeding beauty. At another place men are said to be all white and women of lily-complexion.[23] The dwellers of Kuśadvīpa are stated to be of white complexion.[24] On the Śyāma mountain there are all dark people.[25] (Does this refer to any region of Africa ?). But the author of the Mahābhārata had come to know the general principle of anthropology that in all islands men may be found who are fair and those who are dark, and those also who are born of the mixture of white and black races.[26]

In chapters 47, 48 and 49 of the Anuśāsanaparva also origin of various castes and their intermixture is described.

The Harivanśa, appendix to the Mahābhārata, points to a quite superior methodology of anthropology in the description of the Niṣādas.[26a]

Sources of Smṛtis

From the Baudhāyanadharmaśāstra[27] we learn that the inhabitants of Avantī, Aṅga, Magadha, Saurāṣṭra, Upavṛt, Sindhu and the Suvīras are of mixed origin. The Manusmṛti enumerates a dozen of races—Pauṇḍraka, Cauḍra, Draviḍa, Kāmboja, Yavana, Śaka, Pārada, Pahlava, Cīna, Kirāta, Darada and Khaśa.[28]

The Anuloma and Pratiloma systems of Indian marriages are too well-known. The former permits the highest or higher castes to marry a girl of lower castes, similarly the latter prohibits the higher castes to wed a groom of lower castes. The Dharmasūtras and Manu[29] speak of eight forms of marriage, that is,—

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23. VI. VI. 17-18.
24. VI. 12. 16-17.
25. VI. 11. 22.
26. VI. 11. 21.
26a. Vide Eng. Trans. of Mārkaṇḍeya Purāṇa, foot-note 361.
27. I. 1. 2. 13.
28. X. 44.
29. Manusmṛti, III. 21.

1. *Brāhma*—Where the father confers his daughter, decked with ornaments and jewels, on a learned man of good conduct invited by him.

2. *Daiva*—Where the father offers his daughter, decked with ornaments, to a priest who duly officiates at a sacrifice, during the course of its performances.

3. *Ārṣa*—Where the father gives his daughter after receiving from the bridegroom a cow and a bull or two pairs.

4. *Prājāpatya*—Where the father gives his daughter after addressing the couple with the text : "May both of you perform together your duties."

5. *Āsura*—Where the bridegroom receives a maiden after having given as much wealth, as he can afford, to the kinsmen and to the bride herself.

6. *Gāndharva*—is the voluntary or love union of a maiden and her lover.

7. *Rākṣasa*—is the forcible abduction of a maiden from her home.

8. *Paiśāca*—Where a man stealthily seduces a girl who is sleeping, intoxicated or disordered in intellect.

Generally the authorities have approved the first three, four or six. The last form is universally condemned, and the seventh is commended only in the case of a Kṣatriya.

Kauṭilya also has talked of eight forms of marriage and remarriage of men and women.[30]

The Purāṇas

The development of ethnological and anthropological knowledge in the Purāṇas is remarkable. Apart from imparting conventional knowledge on the subject to us, they have tried to make some original contribution also.

Like other texts the Mārkaṇḍeya and Garuḍa have furnished a very long list of races and tribes. The former refers to the following tribes—Vāhlīka, Vaṭadhāna, Ābhīra,

30. R. Shamasāstri, p. 192, 195, 201.

Kālatoyaka, Aparānta, Pahlava, Carmakhaṇḍika, Gāndhāra, Yavana, Kaikeya, Kāmboja, Barbar, Tuṅgaṇa, Śūlika (near about Oxus), Kerala, and Utkala.[31] The latter speaks[32] of Paṭaccara, Kunta, Śūrasena, Sūta, Māgadha, Kāśyaka, Mūlaka, Aśmaka, Kāmboja, Karṇāṭaka, Draviḍa, Tuṣāra, Khaśa and Mlecchas beyond the Himālayas and Trigarta, Satańkaṇa and others in the north. Besides, both the Purāṇas have referred to numerous other races also, which have been omitted here. They have specified the regions also of various tribes and races, but it does not simplify much of the problem of identification. As identification is not of much value in the present context, any modern good authority may be consulted with benefit. (Cf. fig. 22).

The Bhāgavata enumerates[33] the castes, or communities or peoples of various continents. The Plakṣa is inhabited by हंस, पतङ्ग, ऊर्ध्वापन and सत्याङ्ग who are worshippers of the sun. The Śālmala is peopled by श्रुतधर, वीर्यधर, वसुन्धर and इषन्धर; the Kuśa by कुशल, कोविद, अभियुक्त and कुलक; the Krauñca, by पुरुष, ऋषभ, द्रविण and देवक, and Śāka by ऋतव्रत, सत्यव्रत, दानव्रत, and अनुव्रत and all belong to Vaiśṇava cult and the people of Puṣkara are monotheist. It is not clear what is implied by all these terms and if they represent classifications, what are their *fundamentum divisionis* ? The Viṣṇu Purāṇa[34] also has spoken of various classifications of peoples of those continents. But it is totally different from the former. According to it Plakṣa is inhabited by आर्यक, कुरु, विदिश्य and भावी; Śālmala by कपिल, अरुण, पीत and कृष्ण; Kuśa by दमी, शुष्मी, स्नेह and मन्देह; Krauñca by पुष्कर, पुष्कल, धन्य and तितिरुय; and Śāka by वङ्ग, मागध, मानस and मन्दग; and the Puṣkara is casteless and classless. But this Purāṇa has

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31. Chap. 57.
32. Chap. 55.
33. IX. 20. 30.
34. II. 4. 17, 30, 39, 53, 69 and 79 to 83. (another reading आर्यका कुरवश्चैव विविशां भाविनश्चये—II. 4. 17.

To face P. 230

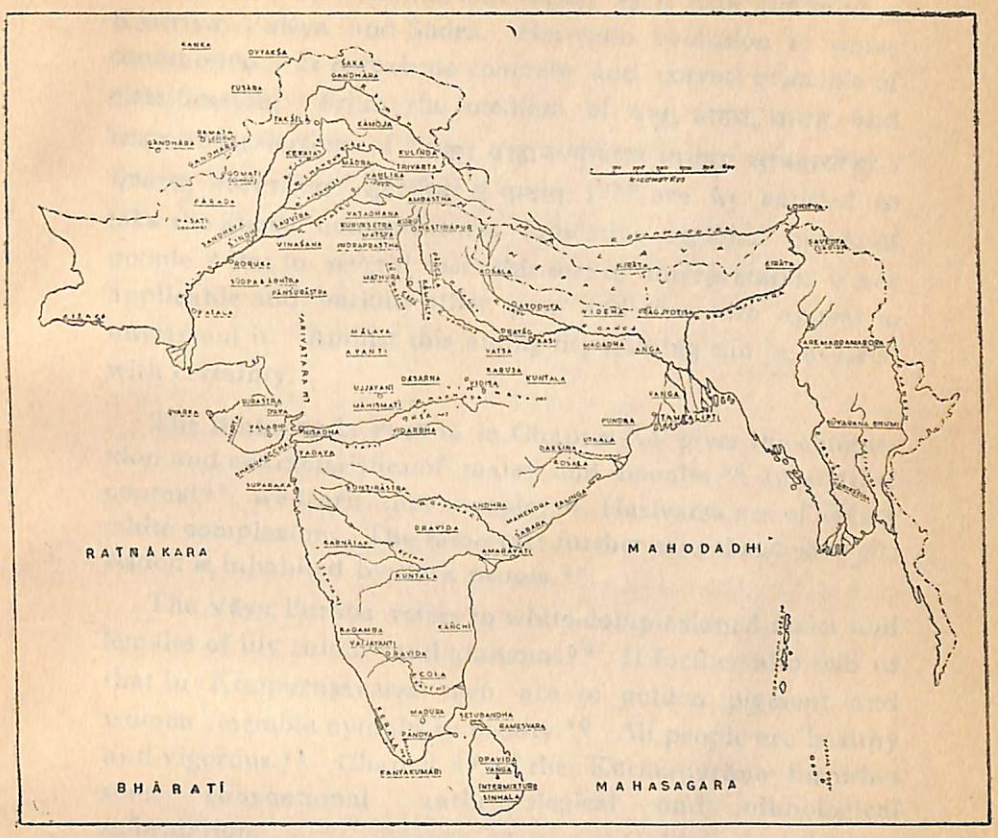

Fig. 22

Physiographical, geopolitical and ethnological complex of Ancient India and the adjoining countries.

Names of races and geopolitical units have a continuous line underneath, those of townships a broken line underneath, and those of Physiography (mountains, rivers, oceans) are without any mark.

associated every time the four classes each with Brāhmaṇa, Kṣatriya, Vaiśya and Śūdra. Here also confusion is worse confounded. It reveals no concrete and correct principle of classification. From the mention of वङ्ग, मागध, मानस and मन्दग and assertion of "वङ्गा ब्राह्मण-भूयिष्ठा मागधाः क्षत्रियास्तथा। वैश्यास्तु मानसास्तेषां शूद्रास्तेषां तु मन्दगाः।"[35] are we entitled to take the above nomenclatures indicating regional names of people ? But in several cases this sort of interpretation is not applicable and various other pros and cons also appear to unwarrant it. Amidst this ambiguity nothing can be averred with certainty.

The Brahmāṇḍa Purāṇa in Chapter XV gives the complexion and characteristics of males and females.[36] In another context[37] we learn that people of Harivarṣa are of silvery white complexion. The same text further says that Śyāmagiri region is inhabited by dark people.[38]

The Vāyu Purāṇa refers to white-complexioned males and females of lily colour and glamour.[39] It further also tells us that in Kimpuruṣavarṣa men are of golden pigment and women resemble nymphs in beauty.[40] All people are healthy and vigorous.[41] Chapter 47 of the Kūrmapurāṇa furnishes some conventional anthropological and ethnological information.

The Padmapurāṇa says that the area adjoining Gandhamādana mountain is inhabited by black men, but there women are lotus-coloured and all beautiful.[42] In Uttara-Kuru males are white and handsome and females are simply

35. II. 4. 69.
36. Pūrvabhāga XV. 59. 63.
37. Ibid XVII. 6.
38. Ibid XIX. 88.
39. 42. 7.
40. 46. 5.
41. Mārkaṇḍeya, Chap. 60.
42. The Padma III. 52-53

heavenly damsels.[43] In Bhadrāśvavarṣa also all classes of people are white in complexion and women are lily-hued, beautiful and attractive. Their limbs are cool and cosy and they are expert in music and dance.[44] But ultimately it is declared that all the continents are inhabited by white and dark people both.[45] The Matsya says that Brāhmaṇa, Kṣatriya, Vaiśya and Śūdra have white, red, yellow and black pigments respectively.[45a]

In the Skandapurāṇa we have got a separate (Kāśī Khaṇḍa chapter 37)[45b] entitled as स्त्रीलक्षणम्, which provides a keen anthropological study of all the parts of a woman's body. It gives the details and measures of various limbs of a female, for example, of chest, waist, forehead, hairs, shoulders, eyes, head, buttocks and other organs. According to the Purāṇa the normal measure of waist of a woman is 24 Aṅgulas (18 inches) and that of chest, 18 Aṅgulas (13½ inches as measured in a particular way)*. If hips are round they are considered as beautiful. Nose may fall in any of the three classes—flat, narrow and long. Her eyes may belong to any of these classes—उन्नताक्षी (bulging eyes), वृत्ताक्षी (round eyes), मेषाक्षी (eyes of a sheep), महिषाक्षी (eyes of a buffalo) and केकराक्षी (squint eyes).

There are three types of heads of women—स्थूल (round and broad), दीर्घ (long), and विशाल (large). The former two can be identified with brachycephalic and dolico-cephalic classes. विशाल perhaps implies the mesocephalic. Their forehead may be semicircular, undepressed and three Aṅgulas broad. Some other facts are also given.

Vṛhatsanhitā

All said and discussed above is simply culled and collected material. But Varāhamihira appears to be really keen, sane

43. Ibid IV. 16-17.
44. Ibid IV. 16-17.
45. Ibid 8. 20.
45a. 113. 114-16.
45b. Vide Garuḍa Purāṇa, Chap. 63-65.

* Compare the body measurements used in modern beauty contests.

and profound scholar of anthropology. In this respect he easily occupies the top position among the ancient anthropologists and ethnologists of India. He has presented also his knowledge quite systematically. He has discussed these branches of knowledge in three chapters (67, 68 and 69) of the Vṛhatsanhitā.[46] They are designated as पुरुषलक्षण (Description of Homo sapiens), पञ्च-मनुष्य-विभागः (Five classification of human beings) and कन्यालक्षणम् (description of damsels) respectively.

Before we take up the anatomy of Vṛhatsanhitā's anthropology, one thing should be observed that the science of सामुद्रिकशास्त्र, which contains a lot of absurd astrological material, was to a minor extent a sort of desultory approach to modern anthropology also.

In the chapter 67, Varāhamihira furnishes anthropological and anthropometrical details of human beings (perhaps mostly referring to man). In this connection he gives facts about height, weight, colour, chest, shoulders, waist, head, forehead, eyes, eyebrows, hairs and so on.

Waist—It may be like that of a lion (slim, sturdy and extremely strong), camel and monkey. On the basis of the authority of other prior treatises, he says that it may resemble that of a dog, jackal and donkey.

Chest—It may be even, flat or small.

Shoulders—They may be of two types—bony and small and large and continuous.

Lips—May be thin or thick. In this connection various quotations are also given.

Nose—There are seven types of noses—1—Śukanāsā (nose resembling the beak of a parrot—recognised as a typical Aryan feature, so eloquently and commendably referred to in the entire classical sanskrit literature as an insignia of

46. Caraka and Suśruta also provide some details of these sciences.

attractive looks), 2—Long nose, 3—small, 4—big, 5—flat, 6—अग्रवक्रा (curved at the end), and 7—ऋज्वी-अल्परन्ध्रा (straight with small holes).

Eyes—They may be resembling those of cat, dear—elliptical and beautiful (specially applicable in the case of women—मृगेक्षणी) and elephant. Our scientist has recognised 'blue eyes' as a distinct class.

On the basis of other authorities, he has recognised three more classes of people—peacock eyed, mongoose eyed, and swan-eyed.

Eye-brows—may be protruding (अभ्युन्नत), large, curved like the moon and depressed in the middle.

Forehead—the most typical are large and bulging, depressed, uneven, half-moon-shaped and small and round.

Head—Varāhamihira has recognised six varieties of heads—round (of brachycephalic people), ऊर्ध्वभागविस्तृत (dolicocephalic), flat, शिरस्त्राणसदृश (resembling a helmet), कुम्भ-सदृश (like a pitcher) and too depressed head. Thus we see that the ancient scientist has presented a better and subtler study of human head than the modern anthropologists, who generally recognised only two or three types of head.

Hair—Ancient Indians did not lag behind in the close study of hair also : It may be thick or thin and then may belong to any of the three classes—बहुमूल (wavy), स्फुटिताग्र (straight) and कुटिल (curly). Here we find three most important varieties known to modern anthropologists.

Colour or pigment of skin—White, red and black are the most important ones.

Height—Varāhamihira speaks of three categories of human heights. It is to be measured in one's own Aṅgulas. The best height 108 Aṅgulas or 81 inches, the mediocre one

is 98 Aṅgulas or 72 inches, and the worst is 84 Aṅgulas or 63 inches. These heights clearly indicate that they were applicable to the stature of people of that time, most probably belonging to the Arayan class, and might have embraced the negroids also. A comparative study reveals that modern stature of Indians has dwindled considerably from that age. The figures given by Vṛhatsanhitā are still very accurately applicable to the inhabitants of Europe and North America.

Weight—Similarly the figures pertaining to weight discussed by Varāhamihira are best applicable now-a-days to the people of Europe and North America only. According to our author 1,000 palas or 160 lbs. are average weight of common people, but below that are bad weight indicating bad physique.

Weight of rich people in higher strata of society is 2,000 palas or 320 lbs.

3,000 palas or 480 lbs. are best weight and generally are those of kings or monarchs.

Varāhamihira gives wonderfully correct mathematical rule for age at which heights and weights of a male and female should be taken. He says that the two should be taken at the age of 25 in case of a man, and 20 in case of a woman, when the average span of life of people is assumed to be 100 years. From this we learn that height and weight should be taken when both the sexes are in their best bloom of life. The ancient writer has devised an accurate formula for finding age at which height and weight of both the sexes should be taken, in case the average span of life of various peoples is fluctuating. According to it that age is given by the following expression : $\frac{\text{Total average span of life.}}{4}$

Chapter 68 discusses the five species of superior class of human beings. They are हंस, शश, रुचक, भद्र and मालव्य.

Hansa—His height is 96 Aṅgulas or 72 inches and span across chest when arms are expanded horizontally is 96

Aṅgulas. He bears red face, gold silhouette and round head, becomes the king of Khasa, Śūrasena, Gāndhāra and Duaba of the Gaṅgā and Yamunā.

Śaśa—His height and span across the chest are each 99 Aṅgulas. His teeth are protruding, eyes are big and cheeks fleshy. He is neither very fat nor lean. He becomes the king of people of Gahwaras. He lives for seventy years.

Rucaka—His height and span across the chest are each 102 Aṅgulas. He has beautiful brows and hair, is red-dark in pigment, bears neck like conch and long mouth, and assumes the rein of Vindhya and Sahyādri mountains together with Ujjayinī. His expectancy of life is 70 years.

Bhadra—His both the aforesaid measures are 105 Aṅgulas. He has got fine skin, broad fleshy chest, mouth like that of a tiger, beautiful nose, equal jointed eye-brows, black curly hairs and weight 2000 palas (320 lbs.). He becomes the ruler of Madhyadeśa and lives for 80 years.

Mālavya—His height and span across the chest are each 108 Aṅgulas. His nose is long, span from the chin to fore-head is 13 Aṅgulas, and earhole is situated at a distance of 10 Aṅgulas from the chin. He bears luminous eyes, pretty cheeks, white teeth, slim waist, arms like the trunk of an elephant and lips which are neither thick or thin. He is to rule Bharukaccha, Saurāṣṭra, Sindhu and region close to Pāriyātra mountain.

From chapter 69 we learn about कन्यालक्षणम्. It gives some anthropological details of damsels or females.

Varāhamihira refers to several precursor authorities, for example, Parāśara and Garga, which are known to have flourished near about the beginning of Christian era or a few centuries earlier. This proves that there must have been a long past tradition of anthropological and ethnological studies and there must have existed numerous such treatises in the times of Varāhamihira.

Bhaṭṭotpala, the commentator of Vṛhatsanhitā, has referred to a work of the name of Sārāvalī. This also appears to have contained at least some material on anthropology. Most probably it was written by Kalyāṇavarman somewhere in the seventh century A. D.[46a] Apart from this, Bhaṭṭotpala himself seems to have been an ardent scholar of anthropology.[46b]

The norm of Indian aesthetics of physical beauty and perfection requires conch-like neck, shoulders like those of a bull, broad fleshy chest, concealed collar bone,[47] broad forehead, arms extending upto thighs, teeth resembling the seeds of pomegranate or white pearls, nose like the beak of a parrot, eyes like a lotus or fish, rosy cheeks and above all robust physique in males ; while lily complexion, slim body and waist, fawn-eyes, red lips resembling ripe Bimba fruit (coral lips), rosy cheeks, thighs like the trunk of plantain trees, round fleshy hips, long eye-corners, tender and fleshy built in females. Symmetry of limbs was recognised to be the first criterion of beauty of both the sexes.

Treatises on Ars Amoris

For our purpose two standard works would suffice. They are Vātsyāyana's Kāmasūtra (prior to Kālidāsa) and Ratirahasya composed round about 1200 A. D. The latter has drawn upon Vātsyāyana and various other sources. Kāmasūtra evinces a long past tradition of assiduous and systematic cultivation of the science of erotics.

Kāmasūtra deals with the description of youths and maids (or males or females), courtship, love, marriage, various theoretical and practical aspects and blisses of conjugal life and decency and decorum of the cultured city life.

46a. Cf. The Age of Imperial Unity of Kannauja, R. C. Majumadar, p. 199.

46b. The Samarāṅgaṇasūtradhāra, Chap. 81 (पञ्चपरुषस्त्री-लक्षणम्) merely repeats the information of Varāhamihira (Chap. 68) with a little variation in details.

47. "गूढजत्रुरिन्दमः" Rama's description in the Rāmāyaṇa.

Vātsyāyana has divided men[48] and women in three classes each. Men may be handsome (शश), hefty (वृष) and giant (अश्व). The three categories of females[49] and tiny (मृगी), tall (वडवा) and hefty (हस्तिनी).

Then he has discussed some of the anthropological characteristics of women of various regions of India, namely Avantī, Mālava, Kośala, Vāhlīka, Dravida and others.

The Ratirahasya,[50] however, modified the classification of women. First of all its author Kokkoka has recognised four feminine species, that is, पद्मिनी (beautiful type), चित्रिणी (artistic type), शङ्खिणी (the plain type) and हस्तिनी (obese uncommendable type). He furnishes considerable anthropological and ethnological details of each type. He thinks that three categories mentioned above in Vātsyāyana's work are merely physiological sub-classifications of these four classes.

In discussing the three classes of males also (शश, वृष and अश्व) he has dwelt on various anthropological information, that is, head, forehead, neck, arm, speech, hair, eyes, lips and teeth and the like.

In chapter V, Kokkoka dilates on anthropological characteristics—psychological and physical traits of women of different regions of India, for example, of Gaṅgā plain, Avantī, Ābhīra country, the Punjab, Gurjara, Mahārāṣṭra, Dravida, Āsāma, Vaṅgāla and Urisa. His masterpiece of erotics and sexual psychology, definitely far superior to the Kāmasūtra in its scientific epistemology, dialectics and marvellous researches in the realm of psychic phenomena of conjugal bliss oftener probing in the recesses of experimental psychology quite successfully dashing even in the domain of something like ultra modern cybernatics and biotins provides valuable information on marriage and social

48. Kāmasūtra Adhikaraṇa 2, Chap. 1.
49. Ibid.
50. I to 11 to 20.

customs, other important anthropological details of routine life and sociological problems and saner approaches to social wellbeing and harmony.[51]

Jain sources

There are very positive grounds to conclude that the Jainas had quite intelligent conception of anthropology and ethnology and their knowledge of these branches of enquiry was not at all inferior to that of the Brāhmaṇas.

The Manuṣyaprajñāsūtra 36, chapter I of the Prajñāpanā gives various anthropological information regarding men, women and mlecchas. It typifies five species of Mlecchas—Śaka, Yavan, Cilāta, Śabara and Barbara. The following sūtra mentions several types of tribes and occupation of people. From the sūtra 38, we learn about numerous classes Deva, Kinnara, Yakṣa, Rākṣasa and Piśāca.

In sūtras 105 to 109 of the Jivajīvābhigama an attempt is made for classification of mankind, but it cannot be said how far it is scientific. It recognises two major classes, which are further subdivided into numerous subclasses. They are A—(i) समूर्च्छिम मनुष्य, (ii) गर्भव्युत्क्रान्तिक; B—(i) कर्मभूमक, (ii) अकर्मभूमक and आन्तरदीपक. It is needless to thrash out these, as the description is of little scientific utility. The Antaradvīpakas have got twenty-eight species एकोरक, गूढ़दन्त,...शुद्धदन्त and the like. The description of these species is a little scientific, at least in its methodology. In the sūtra III some imaginary anthropological dimensions are also given.

The Tatvārthādhigamasūtra III. 36 and its Akalaṅkadeva's commentary provides information about several classes of people and their occupation. In the Tiloyapaṇṇattī[51a] also we come across similar information.

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51. Vide "साइबरनेटिक्स (Cybernatics) तथा बायोनिक्स (Bionics) —दो आधुनिक स्तनंधयों का प्राचीन भारत में जन्म" in "कथाशेष" by Maya Prasad Tripathi.

51a. 6. 34-58.

The Aṅgavijjā (4th century A. D.), however, contains some facts on anthropology. In its chapter 24 there is a classification of people in Aryans and Mlecchas. Pigments of Brāhmaṇa, Kṣatriya, Vaiśya and Śūdra are given to be white, red, yellow and black respectively. Places of human agglomeration are mentioned. Various other facts are also given. The following chapter further provides some detailed ethnological knowledge mentioning the names of different tribes (गोत्र).

The Jīva-Vicāra[52] has spoken of several types of communities and races, for example, Asura, Nāga, Piśāca, Rākṣasa, Kinnara, and the like. Later it furnishes some bizarre anthropological information.

Buddhist Texts :

Buddhist literature is really poor in anthropological and ethnological references and discourses. If at all we meet any such allusions in their literature, which are so scarce, they are extremely brief and cursory. The third Kośasthāna of the Abhidharmakośa has endeavoured in this direction to be a little scientific and systematic, but with lamentably meagre success. The information it furnishes about stature and span of life of various people is all mythical and imaginary and serves no scientific purpose. It however, gives correct facts about the age and stature of the inhabitants of Jambudvīpa. According to this work their height may range from $3\frac{1}{2}$ cubits to 4 cubits and their span of life is uncertain.

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52. Leaves 13-16.

Development of Geographic Knowledge in Ancient India

CHAPTER IX

Survey, Cartography and Cartographical Symbolism

Measurement of land, sacrificial places and Buildings
Survey work
Diagrams of altars and plans of Towns
Map making
Map of India
World map
Orientation
Scale
Projections
Cartograms
Block diagrams
Use of conventional signs
Geographic Instruments

CHAPTER IX

SURVEY, CARTOGRAPHY AND CARTOGRAPHICAL SYMBOLISM

(For more Maps & Sketches refer to Chapter VII also)

The Early Age

At least four quarters were well-known to the Pre-Ṛgvedic Āryans. The Ṛgveda positively knew of all the ten quarters (eight quarters+zenith+nadir) of the space as is clear from various mantras.[1]

Determination of quarters was extremely essential in connection with construction of Vedies (Gārhapatya and Āhavanīya in vogue at that time) which are according to Oldenberg earlier than the Ṛgveda; it was carried on by the observation of the sun, and started with the finding of the east. The Ṛgveda I. 95. 3 speaks of Agni, in his character of the sun, as the indicator of the points of the horizon.

The eastern quarter was the pivotal point of all rituals, religious and liturgical works, practices and ceremonies.[2] This is the first and most profound beginning of the practice of eastern orientation in all construction, drawing, cartographical and engineering works in India which was strictly adhered to in all later vedic literature, Śulvasūtras, Vāstuśāstras and continued uninterruptedly and unchangeably till the time of Maratha cartography.[3]

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1. I. 141. 2 explicitly recognises ten quarters; VIII. 65. 12 speaks of eight points of the sky plus the zenith.
2. VII. 99. 2; III. 8. 9; II. 15. 3 and the like.
3. Vide my paper "Solution of a riddle of Maratha maps" in "Studies in Humanities," Allahabad Universiy, Vol. II. 1958.

This practice of eastern orientation dominated the elaborate Ṛgvedic survey work also as is proved by II. 15. 3. which says, "Surveying like a chamber (or sacrificial chamber), Indra has made this world east-oriented." This mode of eastern orientation was the special characteristic of the Ṛgvedic Āryans and later Indians,[4] very ancient Babylonians recoursed to Northwest orientation and Egyptians to the north. In the later vedic literature and Śulvasūtras the east-west line was called the Pṛṣṭhyā like the north-south line of modern surveyors and cartographers all over the world. In the Taittirīya-Sanhitā we find the first mention of this line.[4a]

Selection of site and very technical measurement and survey regarding the construction of the Vedis are the earliest modes of survey and cartography in India as revealed by the Ṛgvedic hymns (of course, leaving out the Harappa and Mohenjodaro civilization for the present). The concept of surveying is as old in India as her supreme and most appealing cosmogony outlined in the opening chapter. The Ṛgvedic practical and theoretical survey and cartography (though no sample of the age has been recovered so far except mere description), appear in no way to be attempts or instances inferior to Gaisur or the oldest Babylonian cartography.

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4. Prof. H. H. Wilson annotating I. 31. 14 remarks, "This is said to allude to a legend, in which gods, intending to offer a sacrifice, were at a loss to determine the cardinal points, until the perplexity was removed by Agni ascertaining the south." From this it can be easily seen that the Ṛgvedic Āryans, in some way or the other, appear to be first in India and perhaps the whole world to use N-S-points as the initial step for ritualistic or sacerdotal purposes, though excessive veneration for the east dominated and later totally eclipsed and ousted this practice.

4a. VI. 2. 4. 5.

Wooden poles and pegs were used in survey, plan and construction of Vedies apart from the measuring rod. Yūpa (sacrificial wooden posts) also perhaps might have served some survey purposes as is indicated by III. 8. 2-9. Measurement of the heaven and earth,[5] measuring the unmeasured ancient divisions;[6] measuring the heaven and earth with measuring rod[7] and "Varuṇa standing in the region of the air, measureth out the earth with the sun as with a measuring rod,"[8] evidence very grand conception of surveying which was translated into practice in erecting great buildings and large sized vedies where sacrifices were carried on for months and months together.[9]

Measuring or surveying of a field with a measuring rod is mentioned in the Ṛgveda I. 110. 5.

It has been proved beyond doubt that some sort of architecture plan, painting and drawing existed in the Ṛgvedic times. The lines X. 34. 8 and others also clearly speak of a dice-board or इरिण which evidences the knowledge of sketch or diagram drawing also.[10] Hence, there must

5. I. 160. 4.
6. X. 56. 5.
7. III. 38. 3.
8. V. 85. 5.
9. V. 45. 11.
10. "Chess played originally on a board of eight times ten squares was after-wards played on one of eight times eight-squares. Our text cannot be taken as evidence of chess in the fifth century B. C., but it certainly refers to games from which it and draughts have been developed. The Sinhalese Sanna says that each of these games was played with dice and pieces such as kings and so on."— Note 7. p. 9. Dīghanikāya, Eng. Trans. by T. W. R. Davids.

Throwing dice (खलिका)—"In the gambling scene on the Bharahut tope (Cunningham, Pl. XLV, No. 9) there is a board marked out on the stone of six times squares (not six by six)...". Notes 4. p. 10. Ibid.

have existed something in the form of plan-drawing, place or region sketches as a piece of cartography.

During the Vedic period survey and cartography developed equally in both the realms—in agrarian and administrative spheres and in the field of sacrificial science. The latter stressed and achieved the strictest accuracy and punctiliousness in them.

The Vedic Āryans had evolved a concept of representation of earth, as several times it is repeated that, "The earth is the size of altar."[11] Later perhaps concept of scale and representation are combined thus, "He should pile (the fire) of a thousand (bricks) when first piling (it); this world is commensurate with a thousand...."[12] Even three worlds were represented by round balls, "The sacrificer binds on his neck a circular piece of gold with twenty-one knobs sewed up in the black-antelope's skin and strung above his navel on a hempen string of three strands. The gold plate symbolises the sun, that is, Agni and knobs represent the months, five seasons, the three worlds and the sun."[13]

The posterior concept of Kūrma-Niveśa (map in the shape of a tortoise) evolved from the Vājasaneyi-Sanhitā's idea that a tortoise supports the world. According to Uvata and Mahīdhara (the commentators of the Sanhitā) and Griffith[14] in verses 30 and 31 this Kūrma is referred to. Griffith says, "The tortoise may have been chosen with reference to the belief that the world rests upon a tortoise as an incarnation of Viṣṇu."[15] (Cf. fig. 23 on p. 252).

In the Taittirīya-Sanhitā a surveyor is designated as विमान.[16] Āświnas have been recognised as measurer or

11. Taittirīya-Sanhitā II. 6. 4. 1 and II. 6. 4. 3.
12. Ibid. V. 6. 8. 2.
13. English Trans. of Śukla-Yajurveda, Griffith, notes, p. 100.
14. Ibid. p. 118.
15. Ibid. p. 118.
16. V. 4. 6. 5. p. 433.

surveyor of the earth in the Atharvaveda.[17] The Taittirīya Sanhitā describes the survey work performed in the construction of the Mahāvedi.[18] Measuring with a śamyā (yokepin)—a sort of scale, is thus spoken of, "He measures (the altar) round with the yokepin."[19] The verse XX. 132.1 of the Atharvaveda, according to a particular reading refers to measuring rod, its sub-division and survey work.

From the Vājasaneyi-Sanhitā[20] also we learn about the skilful survey of the sky and earth.

On an anterior page of this dissertation it has been said that in the time of the Atharvaveda roads were punctuated with mile-stones,[21] it is a testimony beyond any doubt to the prevalence of the practice of "open traverse survey", without which roads could not be surveyed and measured and marked with mile-stones.

There is a very strong evidence to the fact that some sort of world maps were constructed from the time of the Ṛgveda. The Skanda Purāṇa[22] tells us that there was a custom of पृथ्वीदान—making gift of a copy of the earth or world to the Brāhmaṇas since the time of king Māndhātā and Purūravā. Now the Ṛgveda actually speaks of these two monarchs in its verses X. 134 and X. 95 respectively; naturally, therefore, they must have flourished before the tome.

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17. 12. 1. 10.
18. VI. 2.4.5.
19. VI. 2.7.1.
20. IV. 25 and 30 (Griffith, pp. 31-32); Viṣṇu and his three-steps-measurement V. 18.
21. Chapter VII. p. 160.
22. Nāgarakhaṇda, chapter 268.4-13—

"मान्धाता धुन्धुमारश्च हरिश्चन्द्रः पुरूरवाः।

.....

पृथ्वीदानं पुरा कृत्वा गौतमेश्वसरन्निधौ।"

The Taittirīya-Sanhitā also refers to पृथ्वीदान to the Brāhmaṇas II. 14, p. 253.

It also several times refers to the custom of making munificence to Brāhmaṇas (of course no mention of पृथ्वीदान, resembling the full details and ritual of the Purāṇas is found). But from this we can at least infer this much that some sort of पृथ्वीदान should have been known to the Ṛgveda and its precursors.

And the पृथ्वीदान of the Purāṇas clearly lays down that for this purpose an actual copy, image or accurately speaking a map of the whole world should be constructed on a sheet of gold or silver and on it should be shown all the continents, oceans, mountains, rivers and vegetation, and then that should be given to the Brāhmaṇas. It reasonably points that in observance of this custom or ritual, the Ṛgvedic or anterior people and kings must have got constructed some sort of world map delineating at least some of its paraphernalia.

In this connection a notable point is that the chronological scheme of traditional history as envisaged and calculated in the Vedic Age[23] gives the approximate date of king Purūravā (grandfather of Nahuṣa, father of Yayāti), and Māndhāta to be C. 3100 B. C. and 2740 B. C. respectively.

In the Brāhmaṇas we come across varieties of concepts of representation, though they are more marked for primitiveness and crudeness. But it should not be taken to be a self-contradiction of the above statement of Vedic world map, firstly, because in the Brāhmaṇas merely varieties of concepts are mentioned, which might have had nothing to do with the entire picture and whole process and speed of chronological evolution : secondly, they may have a proneness to be viewed in the same line of reasoning in which we have shown in the opening chapter that the cosmogony of the Ṛgveda is superior to that of the Brāhmaṇas, which were later so involved in gross and ludicrous ritualism, instead of continuing the versatile vedic progress unscathed and without any aberration.

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23. The Vedic Age—R. C. Majumdar (edtd.), p. 270.

The Aitareya Brāhmaṇa has, "The sacrificial post is Yonder sun, the altar, the earth, the strew, the plants, the kindling wood, the trees, the sprinkling waters, the waters, the enclosing sticks, the quarters."[24]

The Śatapathabrāhmaṇa

This Brāhmaṇa is really a mine of information on Indian survey and cartography and on concepts of representation and primitive world map, not only of its own country but perhaps of the whole world—at least to which the epithet "civilized" is applied in modern times.

The text has envisaged various types of representation of the earth, atmosphere and heavens in different shapes of Vedies (Gārhapatya, Āhavanīya, tortoise) and fire-pan (उखा).

The very word Vedi implies the process from which was known through survey and measurement the entire earth. Again its (earth's) representation is also called Vedi constructed on the small piece of ground, as from it we get or visualise the idea or picture of the whole earth. The following two quotations and later discussions would make it all the more obvious that the Vedi is actually the oldest Indian term or synonym for map or any sort of representation.

"They thereupon said: Well then, let us divide this world between us; and having divided it, let us subsist upon it' ! They accordingly set about dividing it with ox-hides[24a] from west to east."[25]

"Having thus enclosed him on all (three) sides, and having placed Agni (the fire) on the east side, they went on

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24. V. 28 —Keith. Compare this concept with those of Marshall Islanders, Eskimos, Amerindians and Aztecs, Raiz, pp. 8-9.

24a. Ox-hide—औक्षणचर्म or गोचर्म is a spatial measure signifying 300′ × 10′ or 180′ × 16.5′. vide गोचर्म M. Williams' dictionary, p. 364.

25. S. B. J. Eggeling—1. 2. 5. 2, p. 59.

worshipping and toiling with it (or him, i. e. Viṣṇu the sacrifice). By it they obtained (sam-vid—संविद्) this entire earth; and because they obtained by this entire (earth), therefore it (the sacrificial ground) is called Vedi (the altar). For this reason say "As great as the altar is, so great is the earth ; for by it (the altar) they obtained this entire (earth)."[26]

The underlined portion in the above passage and analyses in the sequel would further point that the Śatapathabrāhmaṇa refers to some concept of scale also, because only then a very large object or thing can be represented in a very small space or on miniature.[27]

The circular representation of our globe *on a flat plane* is thus referred to, ".. ... and moreover the Gārhapatya[28] is this (terrestrial) world, and this world doubtless is circular".[29]

More vivid and better elaboration of the same is found in the following lines which speak of showing of ocean, its current and their direction in addition :

"And, again, why he encloses it with enclosing stones ; the Gārhapatya hearth is this (terrestrial) world, and the enclosing stones are the waters, he thus surmounts this world with water, it is with the ocean that he thus surrounds it on all sides, and hence the ocean flows round this world on all sides. (He puts up the stones) by turning to the right (or south). Whence the ocean flows round this world (from the east) southwards ; —by means of a dug out (hole or moat), whence flows round this world in a moat.',[30]

The same is repeated thus,[31] "verily, this (brick) built fire-altar (Agni) is this (terrestrial) world : the waters (of the encircling ocean) are its (circle of enclosing stones)."

26. Ibid. 1. 2. 5. 7, p. 60.
27. Vide. 1. 3. 3. 9.
28. Gārhapatya is a circular Vedi.
29. J. Eggeling VII. 1. 1. 37, p. 309.
30. Ibid. VII. 1. 1. 13. p. 301.
31. Ibid. X. 5. 4. 1.

From the above two quotations it is clear that ocean was correctly imagined to be encompassing the entire landmass. It is further proved by the mention of the closeness and relativity of island and water.[32] Some sort of representation of rivers is also discernible in the lines IX. 3. 1. 18-19-20.

The first concept of representation of population by some signs or dots (ancestor of choropleth, demopleth and dot map) is manifest in the following :

"And, again, as to why he lays down a लोकम्पृणा, —the लोकम्पृणा, doubtless, is the nobility (or chieftancy), and these other bricks are the peasants (or clansmen, ...)."[33]

The people of the Śatapathabrāhmaṇa have not only attempted for the representation of the terrestrial globe, but for that of the various parts of the universe also (were first to conceive a notion of celestial map as well). A passage says, "And, indeed, there are only three of them, —the first layer is this very (terrestrial) world ; and the uppermost (layer) is the sky ; and those three (intermediate layers) are the air for .....[34]

The same is expressed more elaborately and concretely.[35] "The first three (bricks) are this (terrestrial) world, the second (three) the air, and the third (three) the sky, the fourth the eastern, the fifth the southern, the sixth the western, and the seventh the northern regions."

In this connection VII. 5. 1. 2-10 of the text are most important, as they influenced or at least bore analogy to the conception of the world map and its cartography all over the world for a very long interval. It says that the universe is of the form of a tortoise. "That lower Kapāla (hemisphere) of it (the tortoise) is this world, for that (Kapāla) is firmly

32. Ibid. IX. 2. 1. 19-20.
33. Ibid. VIII. 7. 2. 2. p. 132.
34. Ibid. VIII. 5. 4. 12.
35. Ibid. VIII. 5. 3. 5.

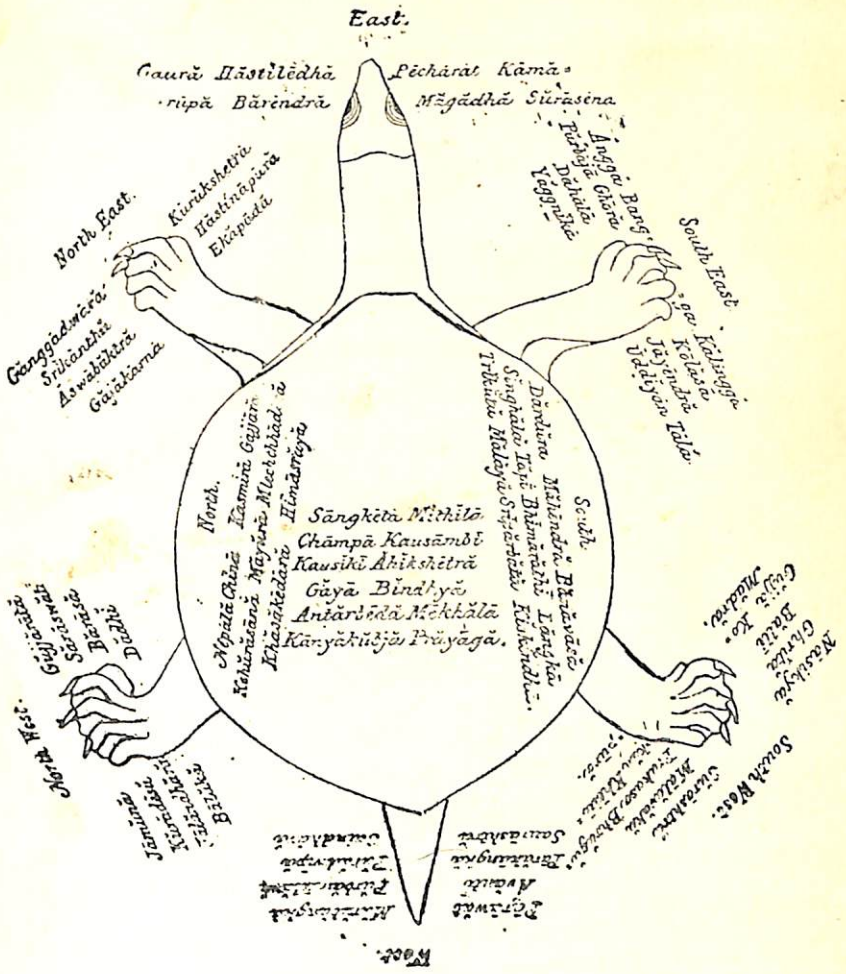
established, and firmly established is this world; and that upper (Kapāla) is yonder sky, for it has its end turned down, and so has that sky its ends turned; and which is between is that atmosphere; verily that (tortoise) represents these worlds." Cf. Figs. 23 & 24. Regarding this notion the Book of Ser Marcopolo translated and edited by Sir Henery Yule remarks, "It may be said with general truth that the world maps current upto the end of the 13th century A. D. had more analogy to the mythical cosmography of the Hindus than to anything properly geographical. Both, no doubt, were originally based on real features. In the Hindu cosmography these genuine features are symmetrised as in a kaleidoscope; in the European cartography these are squeezed together in a manner that one can only compare to a pig in the brawn. Here and there some features strange, compressed and distorted is just recognisable. A splendid example of this kind of map is that famous one at Hereford, executed about A. D. 1275, of which a fascimile has lately been published....."[36] Again the above world map conception of the Hindus wonderfully resembles in shape the mosaic map of Madaba.[37] Cf. Fig. 25.

The Indians of the Śatapathabrāhmaṇa were so enthusiastic about the representation of the universe that they fashioned their fire-pan (उखा) also in such a way as to be a miniature copy of the three world.[38]

Our analysis of the Śatapathabrāhmaṇa speaking of the oldest representation or map of the universe and world is fully supported by the following observations by J. Eggeling, "The very magnitude of the structure;—nay, its practically illimitable extent, coupled with the immense number of single objects mostly bricks of various kinds—of which it is composed, cannot but offer sufficiently favourable condition

36. Vol. I. p. 132.
37. Raiz, p. 25, table II.
38. Cf. S. B. Eng. Trans. vol. IV by J. Eggeling, Introduction, p. XIX.

To face P. 252



Division of Bhavatkhanda into 9 Kingdoms according to the book called Swarodaya.

Fig. 23
Tortoise

This primitive projection was used for representing the whole globular world, heavens, and other areas. (cf. references to Śatapathabrāhmaṇa).

To face P. 252

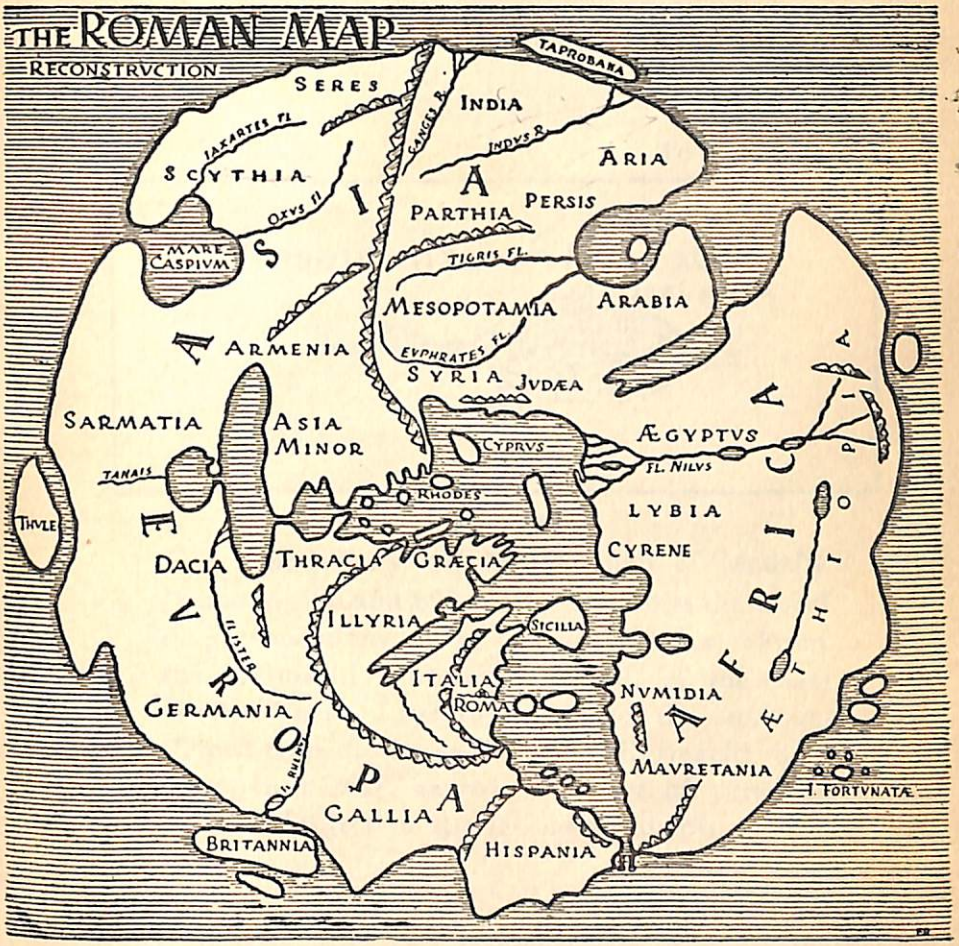
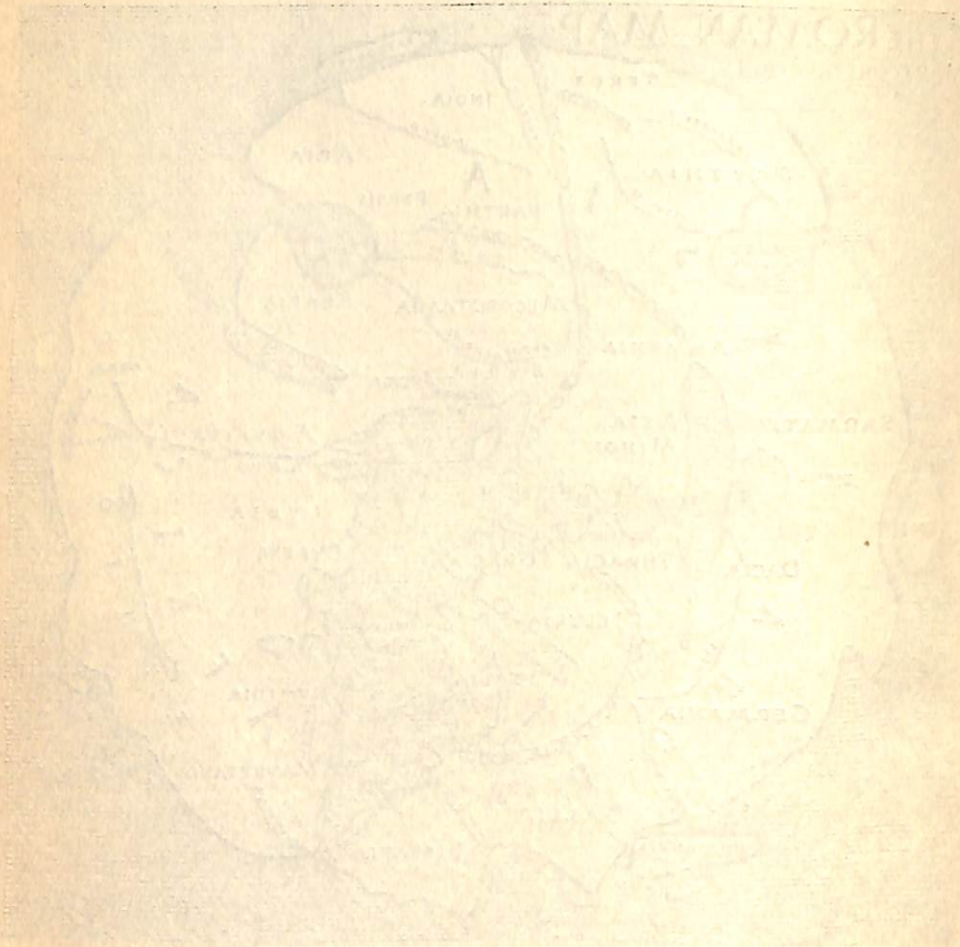


Fig. 24

Orbis Terrarum of the Romans.

This appears to be a modification of the Kūrmanīveśa of the Śatapathabrāhmaṇa, Svarodaya and other ancient Indian Texts.



To face Page 252

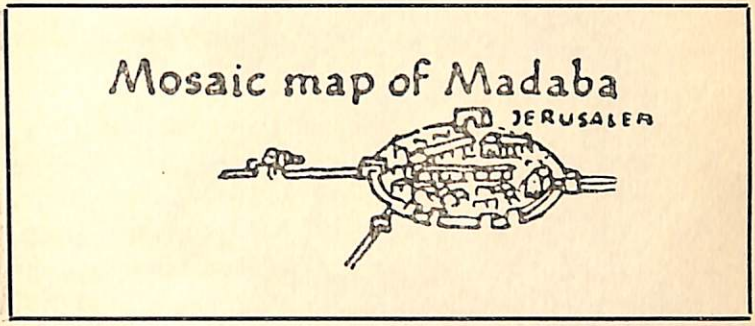


Fig. 25

How wonderfully the Mosaic map of Madaba (between 500 and 600 A. D.) resembles the world map conceptions of the ancient Hindus! From the Kūrmaciti (tortoise shaped pile of the altar) of the Vedic Literature evolved the tortoise-shaped map of the world. This Kūrmaciti, in a sense, in a way, served as a sort of primitive Projection also for various maps.

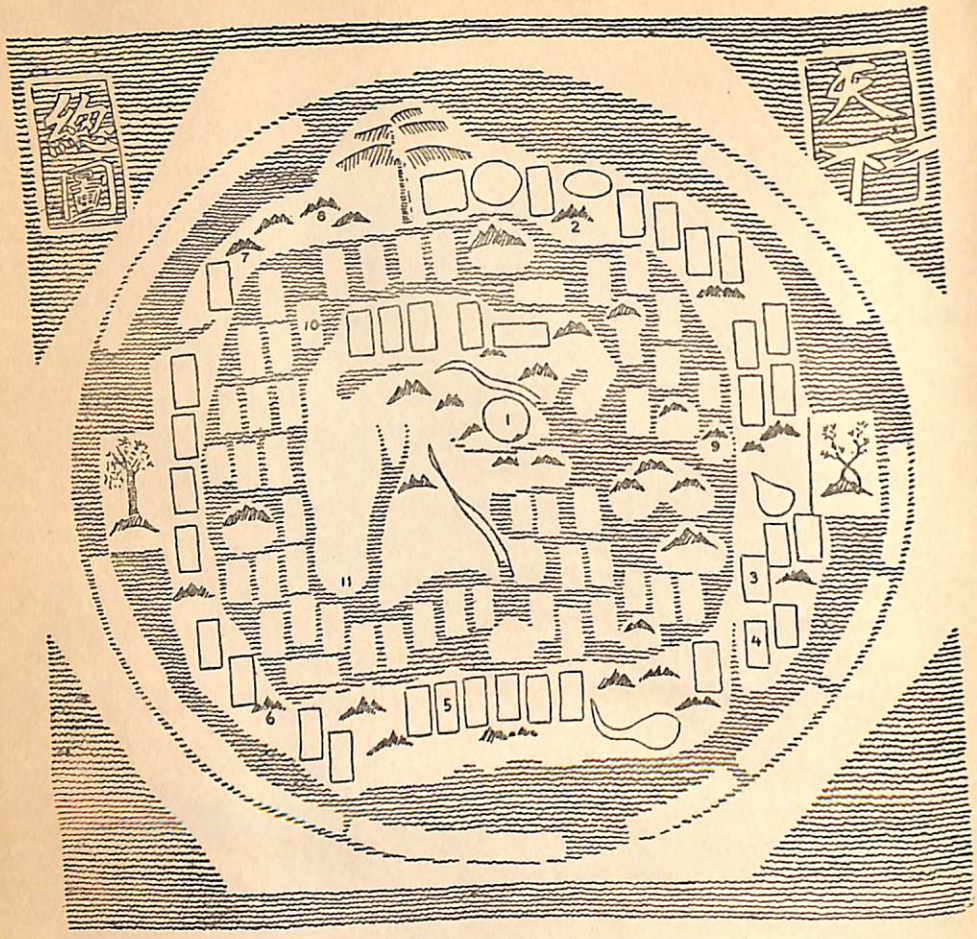


Fig. 26

Ancient Chinese map of the world. [After H. B. Hubert]

Is it not influenced by the Kūrmaniveśa—the tortoise representation of the globe ? Its rectangles are easily comparable to the town-plan-divisions of the Vāstuśāstras of the Hindus.

1—China, 2—The mountain of man's origin, 3—The Land of superior men, 4—The Land of women, 5—Land where it is hard to live, 6—Mountain of fire spirits who control all fire, 7—Great circumference mountains (Maryāda Parvatas of the Purāṇas ?), 8—All white mountains, 9—Pusang (America ?), 10—Land of white People (such people were found in Kuśa-dvīpa according to the Mahābhārata and according to Padmapurāṇa in Uttara-Kuru, did the Chinese not borrow this from the Hindus ?), 11—India (Chinese conception of India resembles that of Dīghanikāya).

for contriving what might fairly pass for a miniature representation of at least the visible universe.

"Side by side with the forming and baking of the bricks for the altar takes place the process of shaping and baking the fire pan (उखा). During the year over which the building of the altar is spread, the sacred fire is carried about in the pan by the sacrificer for a certain time each day. In the same way as the layers of the altar are arranged so as to represent earth, air and heaven, so fire pan is fashioned in such a way as to be a miniature copy of the three worlds."[39]

The whole of the above discussion and S.B. Kāṇda VI and VII reveal that bricks and layers of the vedies represented various parts and regions of the world or sky—various methods of piling bricks in the construction of the vedies always kept that point in view. A word about the brick like or rectilinear representation of the countries or islands[40] in the circular Hindu Vedi (Gārhapatya). Curiously enough in the earliest Chinese map of Pei Hsui[41] (224-273 A. D.) (Cf. Fig. 26) we have the same type of representation, the rotundity of the whole map is also the same as that of the Gārhapatya. Thinking in the chronological channel, are we entitled to warrant any influence of Indian cartographical

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39. Ibid.

40. The concept of representation in Vedies involved or presupposed a notion of the existence or representation of worldly islands and oceans together as is evidenced by the lines, "But let him rather set it out on the fire altar;—for that fire altar is these worlds, and the enclosing stones are waters; so that when he sets out on the fire altar, he indeed sets it out on an island."

    This may be taken as another proof of the fact that construction of world maps must have been in vogue in the Vedic times in the performance of the पृथ्वीदान, which has been discussed in the beginning of this chapter. Tortoise world map is also already dwelt on.

41. Raiz, p. 12.

ideas on those of the Chinese, only further researches can ascertain the reality. From Yule's above work[42] it is further found that the Chinese plans of towns (6th century A. D.) resembled the padavinyāsa (division of ground into squares and rectangles) of the Hindu town plans and were most probably copied from the latter, as we know for definite that Indian astronomy, mathematics and various other sciences including architecture had exercised much influence on China by the 5th or 6th century A. D.[42a]

Survey of the World

Like the Ṛgveda and the Taittirīya-Samhitā the S.B. also speaks of some sort of survey of universe, world or earth. The lines VIII. 3. 3. 5 of the S.B. actually allude to measurement, or survey of terrestrial world, air world and yonder world or heavenly world. The sun has been stated to be the first and the greatest surveyor—he with his rays measures out earth and regions.[43]

Survey and cartography involved in the construction of Vedies

The Kāṇda III of the S.B. fully describes the construction of the altar and hall and dwells on selection of site, determination of its height, evenness, inclination towards east, and then survey and measurement of the ground, followed by actual drawing and construction.

In X. 2. 1-5 and the whole X. 2. 3 are described the measurement of vedi and different measures. The S.B. has discussed the survey and cartography of vedies of various shapes—trapezium, birds (eagle or falconshaped) and śmaśānaciti (pyre) and so on.

In due course the survey, drawing and construction of Vedies assumed the form of a separate full-fledged and rigorous science designated as the "Science of Śulva" or Śulvasūtras.

42. Vol. II, p. 209.
42a. Vide the Classical Age, p. 614-15.
43. VI. 3. 1. 18.

Hence any extract from the S.B. describing the actual processes of survey and drawing of the vedies has not been given here. Illustrative citation, however, would be made in the following section at the proper place, so that the comparative vista of the whole thing and chronological evolution may become crystal clear.

Survey and Cartography in the Śulvasūtras

So far both the oriental and occidental scholars of Indology have studied the Śulvasūtras or the Science of Śulva[44] as an early treatise on Hindus Mathematics, chiefly on Geometry. But as a matter of fact they are primarily the earliest systematic and codified treatises on Hindu survey and cartography which mark out a specific age and compilation of a long conventionally preexisting scattered rules, regulations and literature on the two branches of the most practical learning. They were specifically composed in book-form for sacerdotal, liturgical and building purposes. There must have been much in common in the survey and cartography of the Śulvas and those for the land revenue system, geopolitical or geographical purposes, and also there must have been much mutual impact for the improvement of the two sciences irrespective of the fact in which domain they originated first, though the orthodox precision must have started first in the realm of sacrificial constructions. And as such the Śulvasūtras necessitated and presupposed a knowledge of Mathematics, though they themselves treat of concise mathematical and geometrical postulates, theorems and methods. Śivadāsa (posterior to Sāyaṇa 1320-1380), the

44. Etymologically the word "śulva" is derived from the root "śulv" or "śulb" meaning to measure. Traditionally, however, it had come to have four. meanings—(i) actual mensuration and its processes; (ii) the line or surface resulting from such measurement; (iii) a measure—the surveying or measuring instrument; and (iv) surveying or the art of measuring and concomitant cartography.

commentator on the Mānavaśulvasūtra observes, "The study of the Śulva should be begun after having finished the science of Mathematics, otherwise there cannot be a thorough knowledge of the Śulva." So it is only secondarily that they are or should be considered mathematical work. Similar is the case with the modern surveying and cartography also.

Different Śulvasūtras—Related to the different Vedic schools there are nine texts of the Śulvasūtras in all. Bibhuti Bhushana Dutta[45] mentions seven—Baudhāyana, Āpastamba, Kātyāyana, Mānava, Maitrāyaṇa, Varāha and Vādhula. Louis Renou[46] names two more—Laugākṣī and Hiraṇyakeśī. In wide features the contents of the different Śulvasūtras are the same, except a few occasional innovations and expositions. The present investigation is mainly based on the most important and oldest ones, namely, Baudhāyana, Āpastamba and Kātyāyana-śulvasūtras, though here and there some references to others also would be found.

A word about the time of the Śulvasūtras. On the ground of external and internal evidences, the three most important ones—Baudhāyana, Āpastamba and Kātyāyana (Kātyāyana Śulva Pariśiṣṭa or Kātīya Śulva) can definitely be placed earlier than 400 B. C. and their chronological order is also the same as their enumeration in these lines. The Baudhāyana Śulvasūtra is the oldest one and belongs to C. 1000 B. C., though some scholars are inclined to assign it a date of 2000 B. C.

The older Perspective—The history of the survey and cartography dilated in the Śulvasūtras begins far back in the ages anterior to them. Oldenberg[47] has shown that the three most primitive Vedis—Gārhapatya, Āhavanīya and Dakṣiṇāgni—are older than the Ṛgveda. They can safely be taken back to the era near about 3000 B. C. (on the right or the

45. The Science of the Śulva, p. 1.
46. Vedic India, Table of Vedic School, pp. 50-51.
47. Oldenberg, Religion des Veda, p. 348, n. 2; S. B. E. XXX; p. IX.

left of the same). There must have been only a small hiatus of a few centuries between their age and that of Harappa and Mohenjodaro civilization; since in the latter culture also some sort of sacrificial system[48] prevailed and now consensus of opinions of majority of scholars has drifted to a positivity that there is a link between Harappa and Mohenjodaro civilization and the Vedic one. Rather there are very strong grounds to believe that in the former there was a definite element of the latter or Āryans.[49] Hence from the point of view of evidence of all these sacrificial systems there appears to be a very undeniable ground to surmise that primitive survey work and plan drawing on the ground or stone or the like must have prevailed in 3000 B. C. by the latest.

Again, there is very close similarity between the town-planning of Harappa and Mohenjodaro and the Vedic Vedi (altar) construction and the town-planning of the Mānaṣāra (near about Vitruvius era 25 B. C.)[50] and other Śilpaśāstras. And it is established without any doubt that the Indian Āryan town-planning as found in the Śilpaśāstras or gleaned from other sources was merely developed or modified patterns of Vedi construction. E. B. Havell says,[51] "The close connection of the geometrical system (denoted by the mystic figures Paramaśayika. Swastika, Sarvatobhadra and the like) with the Vedic sacrificial lore, and the position of the master builder as a high priest or sacrificial expert, are indirect proof of the great antiquity of the Indian science of town-planning."..."The laying out of the Indo-Aryan village is treated in the Śilpaśāstras as the preparation of sacrificial

48. The Vedic Age. Ed. by R. C. Majumdar, p. 186.

49. Ibid. p. 195. New excavations at different places (for example Kauśāmbī and others) every day are corroborating further and further this averment.

50. "Architecture of the Mānasāra" by Dr. P. K. Acharya, preface, p. LIX.

51. History of the Āryan rule in India, p. 25.

ground."[52] Binoda Bihari Dutta remarks further, "The plan of the towns and their denominations were identical with those of the geometrical figures, that had to be, and even now, drawn on the sacrificial altars. These figures suggested the plans and the names."[53]

This planning and plan-drawing presupposes and must have had some survey system and cartography. The sum and substance of the preceding paragraph implies that the modes of survey and cartography described in the Śulvasūtras might have originated in the lap of Harappa and Mohenjodaro, or in the age prior to the Ṛgveda by the latest. And it must have been developed and cultivated assiduously and scrupulously in the period preceding to the compilation of priestly rules with contemporary additions and alterations or composition of the Śulvasūtras when they had assumed an 'advanced form", if we say so with reference to the chronological perspective and other purposes of survey and cartography, for example, land holding, land revenue and road-making and the like, where extreme religious rigidity was not required. Thus the vedies were the earliest necessity and impetus to the survey and cartography in India.

As already said, the survey and cartography depicted in the Śulvasūtras must be marked for its precision and advanced state, which must have influenced or from which were derived the principles and methods of survey and cartography prevailing in other spheres of individual or community life. This is supported by the following evidences:

(i) There is clear mention of the field survey or field measurement in the Ṛgveda.[54]

(ii) In the Rāmāyaṇa (800 or 600 B. C.) we find mention of road building, road survey [55] and bridge construc-

52. Ibid. p. 25.
53. Town-planning in Ancient India, p. 7.
54. Vedic Index by Macdonell and Keith, Vol. I, pp. 210-11.
55. The Rāmāyaṇa II. 80.

tion[56] and town pattern—Padmaka (of the lotus shape), Swastika and Vardhamāna[57] resembling the vedies in the Padavinyāsa (division of the ground).

(iii) In the Kurudhamma Jātaka (C. 500 B. C.) we come across an anecdote emphasising exceptional accuracy in land survey.[58]

(iv) A monstrous barrage across the Raivataka mountain was built in the 4th century B. C.[59]

(v) Kauṭilya's Arthaśastra (C. 400 B. C.) definitely mentions land survey and points to map-making and cartography.[60] (vide the sequel)

(vi) Magasthenes also says that the Mauryan government had a very organised survey department and officials.[61]

Contents proper of the Śulvasūtras

In all survey and cartographic work determination of cardinal points is the primary thing. It cannot be said with certainty when Indians came to evolve methods for determining cardinal points. But this much is certain that Harappa and Mohenjodaro people[62] and the Ṛgvedic Aryans[63] knew very well methods for determining quarters. But as already referred to, during the Ṛgvedic age and afterwards for a very long period the sun was the chief medium for finding out the quarters. Perhaps this was the case with Harappa and Mohenjodaro people as well.

56. Ibid. VI. 22.58.
57. Ibid. V. 4.7-8.
58. The Jātak or the stories of the Buddha's Former Birth, edited dy Cowell, Vol. II. p. 257.
59. Ancient towns and cities in Gujarāta and Kathiawār by Dr. A. S. Altekar, p. 22.
60. Chapter XXXV, part I. समाहर्त्ता चतुर्धा जनपदं विभज्य etc.
61. The Age of Imperial Unity. Ed. by R. C. Majumdar, p. 64.
62. The Vedic Age. p. 169.
63. The Ṛgveda 1.95.3.

Kātyāyana gives the method of determining cardinal points from the sun.[64] The Mānavaśulvasūtra gives four methods of determining cardinal directions. [65] Like previous scriptures, the Śulvasūtras also speak of eight compass directions.

The old practice of eastern orientation was continuing as usual. Perhaps Harappa and Mohenjodaro people had the practice of orientation towards the east or north, though this much is sure that their orientation was based on the correct compass directions. The Śatapathabrāhmaṇa gives the reason for eastern orientation. "East is the gate of heaven."[66] "The gods have their birth place in the east, and men in the west."[67]

It is a curious similarity that Christians also had the same religious veneration for the east and the Christian maps between 700 and 1100 A. D. were oriented to the east.[68] The very term orientation points to the eastern quarter.

The above mode of eastern orientation was a natural development and most scientific in those days of yore. Later Romans and Arabs oriented their maps towards south.

Concept of representation—Till the times of the Śulvasūtras there had occurred absolutely no change in the concept of representation, which they appear to inherit directly more from the Śatapathabrāhmaṇa.

Apart from the local mapping and survey and cartography for the administrative purposes of the country, the Indian Āryans of about 2000 B. C. and the succeeding era had, liturgically evolved, as already said, some notion of mapping or representing the entire earth, occasionally even including the sky and intermediate space. When the Vedi was of the

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64. KS. khaṇḍikā 1.2-3.
65. The Science of the Śulba-Dutta, p. 5.
66. SB. Eggeling, p. XXI, p. IV.
67. Ibid. VII. 4. 2. 40.
68. General Cartography—Raisz, p. 25.

form of a quadrilateral, or a square or a wheel, its divisions resembled the modern graticules of Mercator or Gnomonic projections respectively. The figure of tortoise (also of one of the Vedies, discussed in the anterior pages) in the later period served as a sort of map for representing the whole of India.[69] Refer to the Fig. 23 on p. 252.

Concept of Scale—In all sacrificial procedures, the shapes of Vedies were fixed. Their sizes, however, on the different occasions varied tremendously. This gave rise to a very accurate conception of similarity of figures. The latter naturally necessitated a knowledge of some sort of concept of scale. When the altar was enlarged एकशतविध ($101\frac{1}{2}$ fold), the new unit of measure became $\sqrt{14}$ times of the unit of the measure employed for the primitive fire altar.[70] In other words, new Prakrama, Aratni, Pada, Yuga, Śamyā or others (units of length), equalled $\sqrt{14}$ times these for primitive altar.[71] Measurement of administrative areas and revenue lands and its representation on something must have also necessitated some sort of scale.

The very fact that the entire earth could be represented in the form of Vedi, explicitly implied that those Āryans had the clearest conception that a big thing could be shown for convenience on a reduced size, that is, they had some ideas of scale. Further they understood that scale was necessary for enlargement and reduction both of the shapes.

Reduction and enlargement of the Mahāvedī (in the shape of an isosceles trapezium), points to the fact that they had realised the need of and actually used the concept of modern R. F. (Representative Fraction).[72] In reduction of the area to one-third and enlargement to twice to the original

69. It is based on the Sarvodaya, a work earlier than the Bhāgavata—Eastern India by M. Martin, Vol. II. p. 19.
70. The Science of the Śulba, p. 160.
71. Vide. BSL, Chap. I. sūtra 18.
72. Vide. The Science of the Śulba, p. 153-4.

area they employed the R. F. 1 : $\sqrt{3}$ and 1 : $\frac{1}{\sqrt{2}}$ respectively (of course, here the two second numbers of the ratios are not whole numbers).

It can be easily seen that the enlargement and reduction of the plans or maps of Vedies are very much similar to the modern pantographic methods and processes.

Survey and Measurement—How the actual and practical survey work was carried on and how the measurement and cartographical drawing on ground proceeded can be made clear like a picture by the following description :

"From that (the largest post on the east side) one proceeds three vikramas (a unit of measure) to the east and there fixes a pole, this is the middle hind pole (antaḥpātaḥ). From the middle hind pole, he goes 15 prakramas (a measure) towards the south and fixes a pole there; this is the south-east corner(of the Mahāvedī). From the middle hind pole, he goes 15 prakramas towards the north and fixes a pole there; it is the north-west corner. From the middle hind pole he goes 36 prakramas towards the east and fixes a pole; this is the middle front pole. From the middle front pole, he strides 12 prakramas towards the south and fixes a pole; this is the south-east corner. From the middle front pole, he goes 12 prakramas towards the north and fixes a pole there; this is the north-east corner, such is the measurement (survey) of the Mahāvedī."[73]

"Add to the length of thirty-six (i. e. to a cord of the length of thirty-six either Padas of Prakramas) eighteen (the whole length of the cord is then 54), and make two marks on cord, one at twelve, the other at fifteen, beginning from the western end; tie the ends (of the cord of the Pṛṣṭhyā line—the Pṛṣṭhyā is the same as the Prācī, the line directed exactly

73. SB. III. 5. 1. 1-6 (quoted from the Science of the Śulba "pp. 31-32. In the original text, however, the word "Vikrama" is used everywhere for Prakrama occurring in this English Translation. But it is immaterial.

towards the east and west points, and going through the centre of the Vedī. The fixing of Prācī was the first thing to be done when any alter had to be measured out. The methods devised for this end will not be discussed here, as they are based on astronomical observations; for our purpose it is sufficient to know that a line of 36 Padas length and minning from the east towards the west had been drawn on the ground. On both ends of this line a pole was fixed and the ends of the cord of 54 Padas length tied to these poles) and taking it by the sign at 15 draw it towards the south; (at the place reached by the mark, after the cord has been well stretched) fix a pole. Do the same on the northern side (i. e. draw the cord towards the south). By this process two Śroṇīes, the south-west corner and the south-east corner of the Vedī are fixed. After that exchange (the ends of the cord; i. e. tie that end which had been fastened at the pole on the east end of the Prācī to the pole on its west and vice-versa), and fix the two Anśas (shoulder of the vedī, i. e. the south-east corner and the north-east corner). This is done by stretching the cord towards the south having taken it by the mark at fifteen and fixing a pole on the spot reached by the mark at twelve; and by repeating the same operation on the northern side. The results are two Anśas. This is the measurement of the Vedī by means of one cord."[74]

Here the Prācī line or the line joining middle hind pole (śālāmukhī or Antaḥpātaḥ śaṅku) and the middle front pole (Yupātiya śaṅku) from a sort of base line of survey corresponding to the modern base line AB in the plane-table survey for triangulation.

Accurate plan-drawing or map-drawing was in a developed stage is proved by the sūtra 81 of the Baudhāyana-Śulvasūtra.[75] In translating it, Dr. Thibaut writes, "The shape of the Agni is drawn on the ground....." The

74. Āpsl, II. 5 (quoted from "On the Śulvasutras" by Dr. Thibaut J. A. S. Bengal, 1875). Mysore Ed. p. 75-76.
75. Chap. 2. p. 167. The Pandit, Vol. X.

commentator Dvārkanātha Yajvā has called *that map* "रूपाणि"—"तत्र ..पक्षपुच्छादि विभागेन रूपाणि दर्शयेदिष्टकारूपाण्यर्धे-ष्टकापादेष्टकारूपाणि तत्रदेशे यथास्थानं लिखित्वा...त्यर्थः !"

On baked clay-bricks also they drew diagrams like those of the Babylonians found in Gaisur and in the vicinity. This is evidenced by the Baudhāyana Śulvasūtra.[76]

Raisz says that modern division of a circle in 360 degrees is due to the duodecimal system of the Babylonians. But in India the division of a circle into twelve parts was known earlier than the Ṛgveda, as in the preparation of Gārhapatya Vedī (which is definitely earlier than the Ṛgveda) a circle was divided into twelve parts. The earliest śulvakār Baudhāyana refers to it clearly.[77] And this was independent of any foreign influence and perhaps was earlier than the idea of the Babylonians.

From this and the construction of the Rathacakraciti (wheel-shaped pile of vedī) it is evidenced that these Āryans had conception of angles and angular measure also. The clear mention of Āgneya (south-east), Naiṛtya (south-west), vāyavya (north-west) and Īśāna (north-east) koṇas (angles) also point to the validity of the same. There are devices for drawing rhombus, and parallelogram which indicate that they had an idea of angular measurement. It was called Nata (नत).[78]

Triangulation, Squaring and Rectangulation—Various forms of vedīes and their preparation or piling with bricks proves the division of areas into triangles, squares and rectangles. This triangulation resembles the modern one. Later town-planning also followed this method of division of areas.

This method of division of land was followed upto very late times (c. 18th century) in surveying the country. The following quotation will prove this assertion :

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76. Chap. 2. sūtra 43. (The Pandit, Vol. X, p. 143).
77. BSL Chap. 2. sūtra 71. (The Pandit, Vol. X, p. 166).
78. The Science of the Śulba, pp. 67-70.

"The indigenous method of land measurement by simple geometry is commented on by Macrabie, brother-in-law and private secretary to Philip Francis—

"We drove out again to the gardens. I have been talking all round and showing the boundaries to a black surveyor. How the plague these people measure land, I cannot conceive. They neither use the compass nor take sights as our people do, yet they get contents of the ground with tolerable accuracy. It is by means of square, I believe."[79]

Though Europeans already had arrived in India and begun to influence the country in various ways, still the indigenous method of survey was continuing without being affected in the least. Their accuracy, simplicity and suitability have already been testified to, in the above quotation. But from this it should not be construed that ancient and medieval Indians did not know the use of compass or plane table. Sufficient evidences are available to prove that they knew the uses of the two instruments. Compass has already been discussed in the chapter VI. The sequel incorporates facts about the plane table. Perhaps the above quotation refers to a singular parochial custom.

Concept of Levelling—In all survey work concept of levelling is indispensable. In the Kātyāyana-Śulvasūtra we find mention of the same. On an anterior page it has already been shown that the SB fully knew about levelling.[80]

For the survey and cartographical work, the Śulvasūtras had definite sets of measures which were wonderfully subtle and clearly defined. The smallest unit could measure nearly a one-third of the milimeter.[81] Kātyāyana gives still smaller unit which could measure nearly one-fortieth of a milimeter.[82]

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79. Historical Records of Survey of India by R. H. Phillimore, Vol. I, p. 134.
80. Cf. the anterior page of this chapter.
81. BSL. chap. I, sūtra 4.
82. Verse 30, p. 42.

Instruments of measurements—In this surveying and cartography, the following instruments were used :—

1. Ox-hides (Aukṣṇa carma) a sort of spatial measure for measuring ground.[83]
2. Bamboo-rod,[84] sticks and canes.
3. Rope or cord.
4. Poles.
5. Gnomon.
6. Śamyā (a ruler of 36 or 32 Aṅgulas, one aṅgula=$\frac{3}{4}$" nearly).
7. Sphya—wooden sword for drawing line etc.

The Āryans of those days performed geometrically what the Romans did with Groma.

In Harappa a broken rod with graduation marks has been found.

The cord used for these purposes had different marks like measuring tape of the modern times. The Mānavaśūlvasūtra says that it had five joints (Pañcaṅgī) two ties and three marks.

Kauṭilya, perhaps almost contemporary of Katyāyana Śulvasūtra, mentions a measure Rajju which was nearly 60 ft. resembling the modern Gunter chain.

Those well-versed in the Science of Śulva were quite expert in plotting and drawing the very complicated figures of various types of Vakra-pakṣa-śyena-citi (a falcon or hawk-shaped-pile),[85] kaṅkaciti (kite or heron-shaped-pile)[86] and Ratha-cakra-citi (wheel-shaped-pile) and also knew the drawing of triangle, rhombus, parallelogram, rectangle, square and circle[87] and determination of the areas of these, it proves that they could perform survey of any plot of

83. Explained on p. 249.
84. Maitrāyaṇī-Sanhitā, III. 2. 4.
85. Cf. the Pandit, Vol. X, pp. 211-13.
86. Ibid. new series, Vol. I, p. 323.
87. The Science of Śulba, chap. IV.

land[88] how-so-ever complicated and irregular and calculated its area.

But division of ground into squares and plotting of details in them had become a more general practice in later times.

A Comparative study—Encyclopaedia Britannica[89] says, "It is very probable that surveying had its origin in ancient Egypt." Raisz observes,[90] "For purposes of taxation the land was carefully measured and registered and the boundaries marked. Ramses II (1333-1300 B. C.) initiated a systematic land survey of the empire." Similarly Babylonian art of cartography is also considered to be of great antiquity. Some assign it a date of even 2500 B. C.[91] Whatever be the antiquity of survey and cartography in these lands, if we make a comparative study of the former two with India, it would be found that these two branches of practical sciences are still older in the latter country. Harappa and Mohenjodaro plannings (of at least 3000 B. C.), measurement and construction of the Vedīes coming down from an age prior to the Ṛgveda and accurate measurement of land mentioned in the Ṛgveda[92] obviously and very easily prove this.

The survey, planning and cartography of very large Vedīes like Aśwamedha and others were conclusively superrior to those required and performed in the construction of the biggest Pyramid (Khufuś 2898-2875 B. C.) of Gizeh in Egypt covering a volume of 85,000,000 cubic feet and height 481 feet.[93] In laying out the Aśwamedha vedī survey of no less than $\frac{85,000,000}{481} = 180,000$ square feet had to be carried on very accurately. And most probably this was carried on in India near about the same date as in Egypt.

88. Ibid. chap. V.
89. (1959 edition), Vol. 21, p. 609.
90. General Cartography, p. 11.
91. Ibid, p. 12; Antiquity, September 1935, ancient Babylonian maps and plans by Eukhard Unger.
92. Vedic Index, Macdonell and Keith, Vol. I, pp. 210-11.
93. History of the World, J. A. Hammerton, Vol. I, p. 509.

In the very recent excavations of Kauśāmbī, the remains of a śyenaciti (Hawk-shaped-pile of the altar) has been discovered belonging to several centuries before Christ. In it several portions of the plan and plotted points (like Aṣāḍha brick, Lokampriṇā, Prāṇabhṛt bricks and so on) are intact. Since it must have entailed actual drawing and plotting on the ground as on a flat plane sheet, we may take this relic, if we like, as a cartographic specimen of ancient India, since other better examples of cartographic remains have not been unearthed so far.

The Rāmāyaṇa

The Science of the Śulva was thriving well in theory and practice both is evidenced by the Rāmāyaṇa also. It has the following lines—[94]

इष्टकाश्च यथान्यायं कारिताश्च प्रमाणतः ।
चितोऽग्निर्ब्राह्मणैस्तत्र कुशलैः शुल्वकर्मणि ।।
स चित्यो राजसिंहस्य संचितः कुशलैर्द्विजैः ।
गरुडो रुक्मपक्षो वै त्रिगुणोऽष्टादशात्मकः ।।

Then in the canto 80 of the Book II we come across two words which signify that survey and cartography were developing satisfactorily. The words[95] are भूमिप्रदेशज्ञ = having knowledge of reconnoitering, and सूत्रकर्मविशारद = expert in surveying, measurement and cartography.

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94. I. 14.28-29.

95. II. 80.1 (अथ भूमिप्रदेशज्ञाः सूत्रकर्मविशारदाः). These words have been wrongly translated in the Eng. version of the Rāmāyaṇa by MND. Similar words occur in the Māyāmatam 5.17-19 "सर्वदेशज्ञ .....सूत्रग्राही, सूत्रदण्डप्रपातज्ञ" which have been explained by B. B. Dutta in his "Town Planning in ancient India" pp. 167-8 in the same way, as the present author has done above. The detailed discussion on the Māyāmatam would be furnished later under the heading "Architectural sources".

The work of surveying was performed at the time of the construction of bridge on the ocean. The text says,[96] ".....सूत्राण्यन्ये प्रगृह्णन्ति, ह्यायतं शतयोजनम् । नलश्चक्रे महासेतुं मध्ये नदनदीपिते...." Measuring rod was also used,[97] "दण्डान्यन्ये प्रगृह्णन्ति विचिन्वन्ति".

The Yuddhakāṇḍa and different references[97a] point that war-planning and accompanying cartography had reached a high standard of dexterity. Townplans of various shapes mentioned in the Rāmāyaṇa have already been referred to in the preceding pages.[98]

In ancient times the word गणक included all the three surveyors, engineers and computors and mathematicians. Hence the word Gaṇaka in I. 17. 7 implies surveying and surveyors also.

The Mahābhārata

This epic refers to the construction of a plan or map thus—"...विमानप्रतिमां चक्रे पाण्डवस्य शुभां सभाम्"[99] "...He drew up a design of an auspicious palace for the Paṇḍavas". Here the word प्रतिमा has been used in the sense of a map or plan. In wars and army campaigns maps and plans were indispensable. The Bhīṣmaparva refers to several types of war arrays or plans मकर, मण्डल, वज्र and सर्वतोभद्र.

For administrative purposes and drawing of maps survey is essential. In this connection the following lines deserve our notice "तं देशं मापयामासुः यज्ञायतनकारणात्."[100] (They surveyed and measured that country for the construction of sacrificial place). Another line reveals that very gigantic survey work also was undertaken and performed—"दशकिष्कुसहस्रां तां

96. VI. 22.58-59.
97. VI. 22.60.
97a. II. 100. 70.
98. V. 4. 7-8.
99. II. 1. 13.
100. I. 51. 10.

मापयामास सर्वतः" [101] "Then he surveyed 5000 cubit square (nearly $1\frac{1}{2}$ square miles) of land".

The Harivanśa, appendix to the epic, speaks of very large scale survey and plan-drawing or accompanying cartography in connection with the building of town Dwārāwatī thus[102]—कारयिष्ये चिह्नान्यायतनानि च" ॥७॥; "यथानिवेशं सहृष्टाश्चक्रुर्वास्तुपरिग्रहम् ॥११॥; सूत्रहस्तास्ततोमानं च कुर्यादवसत्तमाः ॥१२॥ and स्थपतीनथ गोविन्द ॥ १३ ॥

The Harivanśa further informs us that the first survey of the world was performed in the period of Vaivasvata Manvantara (at least 5000 years ago) and then towns, villages and commercial highways were built. Three verses[103] purport to say that formerly the earth was all uneven and there were no towns, villages, demarcation of agricultural and pasture lands and roads, but when the reign of King Pṛthu came in Vaivasvata Manvantara all these were introduced. Thus we find a faint reference to the history also of survey and cartography in this work. Near about this period an Indian monarch made the exploration and survey of Egypt and perhaps got prepared a map also of the region.[104]

Manusmṛti

The Manusmṛti speaks of six types of war plans[105] दण्ड, शकट, वराह, मकर, गरुड and सूची. Military officers and kings must have been quite well-versed with these plans and relevant cartography.

In the revenue sphere some sort of elaborate land survey and allied mapping must have been prevalent for determination of boundaries, which were carefully marked by trees, raised mounds, stones, bricks and the like.

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101. II. 1. 20.
102. Viṣṇuparva, chap. 58.
103. Harivanśa parva 1. 6. 12 to 15.
104. Manudharmaśāstra by K. Motwani, p. 271 to 274.
105. VII. 187.

The following verse[106] definitely proves the existence of the system of mapping—

ते पृष्टास्तु यथा ब्रूयुः समस्ताः सीम्नि निश्चयम् ।
निबध्नीयात्तथा सीमां सर्वांस्तांश्चैव नामतः ॥

The commentator kūllūka Bhatta explains this, "...प्रकारेणाविस्मरणार्थं पत्रे सीमां लिखेत्....." "In this way so that it may not be forgotten, the boundary should be marked or mapped on a sheet (पत्रे)." The word "निबन्धयेत्" in this very sense is used in Kauṭilya's Arthaśāstra also.[107]

Pāṇini

Ample information regarding the practice of survey is forth-coming from the Aṣṭādhyāyī. In Pāṇini's time village boundaries were marked by प्रस्तार[108]. The entire land under plough was divided into fragmentary holdings (क्षेत्र) which were specifically defined as plots where crops were grown. There appears to have existed a practice of grouping of field also, for which the term "kaidarya"[109] was used, most probably it points to some sort of consolidated holdings. All these go to signify that a systematic survey of agricultural land must have been undertaken and carefully carried out. There was a special class of officers known as "क्षेत्रकार"[110] to perform this work smoothly and efficiently. They surveyed and measured out each field (inferentially must have prepared field books also) and fixed its area (क्षेत्रभक्ति) in terms of kāṇḍa measure. A sūtra runs द्विकाण्डक्षेत्रभक्तिः "a field having an area equal to two Kāṇḍa measures." Then the whole village land was marked out for different purposes.

106. VIII. 255.
107. Cf. the posterior section.
108. IV. 4. 72. The whole succeeding discussion on Pāṇini is based on "India as known to Pāṇini" by Dr. V. S. Agrawal.
109. Aṣṭādhyāyī IV. 2. 40.
110. III. 2. 21.

Thus from the Pāṇinian sūtras it is unambiguously clear that the need and importance of cadestral survey was fully realised and it was performed in some way or other to suit the administration and peasants both at once.

Kauṭilya and his successors

In the opening sūtras of the chapter XXIV, there occurs an expression "कृषितन्त्रशुल्ववृक्षायुर्वेदज्ञ."[111] Here the term "शुल्व"[112] indicates beyond doubt the "Science of Survey and Cartography," since by the time of Kauṭilya the Śulva-sūtras were fully developed and crystalised, rather in all probability the great economist and politician was contemporary of the last of the greatest Śulvakaras, that is Kātyāyana.

Information on land utilization or cadestral survey and the concomitant preparation of necessary maps can be easily gathered from the following lines[113]—

"Having divided the kingdom (Janapada) into four districts, and having also subdivided the villages (Grāma) as of first, middle and lowest rank, he shall bring them *(or register—mine)* under one or another of the following heads—Villages that are exempted from taxation (Parihāraka); those that supply soldiers (Āyudhīya); those that pay their taxes in the form of grains, cattle, gold (Hiraṇya) or raw material (Kupya); and those that supply free labour (Viṣṭi), and dairy produce in lieu of taxes (Karapratikara).

"It is the duty of Gopa, village accountant, to attend to the accounts of five or ten villages as ordered by the collector-general.

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111. R. Shamaśāstri, p. 142.
112. Shamaśāstri has given the reading "गुल्म" for "शुल्व," but it is *prima facie* wrong for the term "वृक्षायुर्वेद" includes the science or knowledge of "गुल्म," there was no need at all to make an absolutely redundant repetition specially at the same place.
113. Chapter XXXV, p. 178.

"By setting up boundaries to villages, by numbering plots of grounds as cultivated, uncultivated, plains, wet lands, gardens, vegetable gardens, fences (Vaṭa), forests, altars, temples of gods, irrigation works, cremation grounds, feeding houses (Sattra), places where water is freely supplied to travellers (Prapā), places of pilgrimage, pasture grounds and roads, and thereby fixing the boundaries of various villages, of fields, of forests and of roads, he shall register gift, sales, charities and remission of taxes regarding fields "

In Chapter XX Kauṭilya has spoken of a high dignitary "Surveyor-General and Survey Department." Here he describes in detail the various linear measures, with which even the smallest length can be measured out accurately.

Once talking of a measure, he says, "This measure is used in measuring roads and fort-walls."[114] From this it is evident that they definitely performed somehow or other some sort of open and close traverse survey both. Mention of circular plans of towns and camps point to the same thing.

From the following lines, it appears that elaborate plans and sketches must have been prepared for army encampment:

"On a site declared to be the best according to the science of buildings, the leader (Nāyaka), the carpenter (Vārdhaki), and the astrologer (Mauhūrtika) should measure a circular, rectangular, or square spot for the camp which should, in accordance with the available space, consists of four gates, six roads and nine divisions."[115]

Various types of army arrays,[116] for example, crocodile array, cart like array, diamond like array (in four or five rows, each having its front, rear and sides) and the like further point to the use of cartography for military purposes.

In the Śukranīti also we read about several special types of army arrays, crocodile-shaped, hawk-shaped, octogonal and wheel-shaped.[117]

114. Shamaśāstri, p. 132.
115. Ibid X. 1. p. 437.
116. Ibid X. 2. p. 439.
117. Śukranīti, B. K. Sarkara, lines 527 to 533.

The Śukranīti refers to a system of a separate minister who was incharge of cadestral settlement or Survey Department and was designated as "Amātya"—Cadestral settlement or Survey Minister.[118]

The Golden Period

The Purāṇas

Before we take up the discussion on actual survey practice as described in the Purāṇas, it is necessary to observe that, like the Vedic literature, they have also referred to the survey of the whole universe. The Matsya says "भुवः प्रमाणं सर्वत्र ज्ञात्वा..." "On hearing the above words of the sage Nārada, the sons of Dakṣa started to survey the length and breadth of the universe."[119] "First examine the extent of the universe, then carry on the work of creation."[120] In the same strain the Varāha Purāṇa[121] has, "एवमुक्त्वा दिवोभूमि मापयमास वै पुमान्." (Having said this he surveyed and measured the earth and the sky).

Various Purāṇas have spoken of the apportionment of the whole earth into seven continents, and again division of each continent into numerous parts.[122] This presupposes that those Indians had good concept of very large scale survey and measurement; because arbitrary divisions of land could have created feud among the sons and descendents of Manu.

It becomes all the more unambiguous when we read the following lines of Viṣṇu Purāṇa.[123]—

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118. Ibid. line 172, p. 71.
119. Ibid V. 7.
120. Ibid. V. 10 and (भुवः प्रमाणं सर्वत्र ज्ञात्वोर्ध्वमध्य एव च— V. 6).
121. 7. 6.
122. The Mārkaṇḍeya 53. 20, 21 to 32. The Viṣṇu—II. 1. 11.
123. I. 13. 82-83-84.

न हि पूर्वविसर्गे वै विषमे पृथिवीतले ।
प्रविभागः पुराणां वा ग्रामाणां वा पुराभवत् ॥
न सस्यानि न गोरक्ष्यं न कृषिर्न वणिक्पथः ।
वैन्यात्प्रभृति मैत्रेय सर्वस्यैतस्य सम्भवः ।

"Before this the surface of the earth was irregular, and there was no boundary of villages and cities. There was no cultivation, no pasture, no highway for merchant ; all these originated O Maitreya in the reign of the son of Vena."

We can, therefore, reasonably conclude that first elaborate survey was carried on in the time of Pṛthu, the son of Vena near about 3400 B.C.[124]

The Agni Purāṇa refers to survey work thus[125]

"रक्तस्रग्वसनाः सीमा नयेयुः क्षितिचारिणः"

".....and the surveyors, clad in red clothes and wearing garlands of red flowers, should be engaged to lay down the boundary."

The Brahmapurāṇa, as in the Rāmāyaṇa, uses the term गणक to imply engineers and surveyors simultaneously—

आनाय्य गणकान् .....वास्तुविद्याविशारदैः[126]

"Having sent for engineers and surveyors together with architects."

From the following lines of the Brahmāṇḍa Purāṇa,[127] we learn about surveying, several types of plans and accompanying cartography :—

"आरब्धास्तान्निकेतान्वै कर्तुं शीतोष्णवारणम् ।
ततस्तान्निर्मयामासुः खेटानि च पुराणि चः ।
ग्रामाश्चैव यथाभागं तथैव नगराणि च ।
तेषामायामविष्कम्भाः सन्निवेशान्तराणि च ॥
चक्रुस्तदा यथाज्ञानं मीत्वा मीत्वात्मनोऽङ्गुलैः ॥ ९५ ॥"

.....

124. Manudharmaśāstra, Motwani, p. 271.
125. 257.3.
126. 47.2-3.
127. Pūrvabhāga, VII. 93-94-95.

Various types of town-planning, demarcation of boundary by survey and measurement are thus alluded to in the Vāyu Purāṇa.[128]

नगराद्योजनं खेटं खेटाद् ग्रामोऽर्धयोजनम् ।
द्विक्रोशं परमा सीमा क्षेत्रसीमा चतुर्धनुः ।।

The above Purāṇas in the same continuation reveal that extensive and accurate survey was carried on for the laying out and construction of different types of roads linking the various patterns of human agglomerations.

The Agni Purāṇa[128a] furnishes a lot of material on surveying and cartography practised in connection with map-drawing or plan-preparation of various types of towns. It has mentioned towns of different shapes, for example, Candrārdābha (semi-circular), Bajrasūci (diamond-shaped or octogonal), Cāpābha (bow-shaped), some of these towns measured several miles in dimension—four or eight miles. The Purāṇa also discusses very intricate war-plans or campaign maps.[128b] A verse[128c] speaks of plan-drawing thus—".....and a diagram consisting of sixty-four rectilinear chambers, should be delineated on the same (ground)."

The Garuḍa-purāṇa (chapter 46) also evinces that it was fully acquainted with various types of maps and plans of fort or fort-cities and general towns.

In the Matṣya Purāṇa[128d] there are several references to architectural cartography. A verse speaks of division of eighty-one chambers and another of sixty-four.

In the Brahmavaivarta[128e] the draftsman or cartographer has been called the son of Viśwakarmā, thus it denotes

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128. VIII. 117.
128a. Chap. 106.
128b. Ibid. chap. 242. 38 to 59.
128c. Ibid 247 4.
128d. Chapter 253.
128e. Brahmakhaṇḍa 10-90.

a particular class of people who specially undertook the aforesaid profession. The fuller treatment of this survey and cartography would be found in a subsequent section "Architectural treatises."

Concept of Geodetic survey

In the Śivapurāṇa[129] occur these lines—

अस्त्युत्तरस्यां दिशि वै गिरीशो हिमवान् महान् ॥१४॥
पूर्वापरौ तोयनिधी सुविगाह्य स्थितो हि यः ।
नानारत्नाकरो रम्यो मानदण्ड इव क्षितेः ॥ १६ ॥

In Kālidāsa also we have effusions of similar ideas—

अस्त्युत्तरस्यां दिशि देवतात्मा
हिमालयो नाम नगाधिराजः
पूर्वापरौ तोयनिधीवगाह्य
स्थितः पृथिव्यामिव मानदण्डः ॥ (Kumār I. 1).

"There is the Himālayān mountain, esteemed like a deity, in the north of Bhārata. It stretches from the eastern ocean to the western one, as if it were a measuring rod for the measurement of the earth."

Here it is immaterial for us whether Kālidāsa borrowed the ideas from the Śivapurāṇa or the vice-versa or both state the particular fact independently. We are concerned merely with the scientific aspect of the assertion. Now the question arises whether ancient Indians had some notion of geodetic survey, and is the same glimpsed by the lines of the two works ? As various facts and concurrence of evidences indicate the answer is in affirmative. The two astronomical treatises, Brahmasiddhānta and Somasiddhānta, written between 500 to 821 A. D. bear indisputable testimony to this. The former states, "वृत्तस्य षण्णवत्यंशो दण्डवच्च समः स तत्",[130] the latter also has "भचक्रात् षण्णवत्यंशा समभूया च सैव हि."[131]

129. II. 3. 1. 14-16.
130. p. 12. verse 93.
131. p. 6. verse 1.

"The 96th part of a circumference is nearly a straight line." Thus we see that they knew and took into account the curvature of the earth.

As in modern times occasionally maps or representations are made with bricks, gravels, grasses, cement and other materials for exhibition, decoration and other purposes, similarly in Pauraṇic times some such sorts of representation were in vogue, of course, for religious purposes in the gift making ceremonies. In the Matsya Purāṇā there occurs a chapter Dāna-Māhātmya[132] which furnishes abundant information on this point.

It speaks of preparation of the Meru mountain, others and Viṣkambhaparvatas with rice[133] and Gandhamādana[134] with wheat. Rock-structure and flora were shown with various devices as is indicated by [135]

..... पूर्वेण मुक्ताफलवज्रयुक्तो याम्येन गोमेदकपुष्परागैः
पश्चाच्चगारुत्मतनीलरत्नैः सौम्येन वैदूर्यसरोजरागैः
श्रीखण्डखण्डैरभितः प्रवालैर्लतान्वितः शुक्तिशिलातलः स्यात् ।

Summits, foothills, dales or ravines and numerous streams were also included in this representation.[136]

चत्वारि शृङ्गाणि च रजतानि नितम्बभागेष्वपि राजतः स्यात् ।
तथेक्षुवंशावृतकन्दरस्तु घृतौदकप्रस्रवणैश्च दिक्षु ।

The exhibition of forests and lakes or oceans were also made—क्षीरारुणोदसरसारपयसाऽथवानेन चैवं रौप्येण शक्तिघटितेन विराजमानम्— Rather the whole chapter is replete with such ideas of representation.

Map-making and diagram drawing were definitely known and practised, specially in connection with astronomical

132. Chap. 83.
133. 83.11 & 13.
134. 83.22.
135. 83.13-14.
136. 83.16.

studies, which positively included geography also, is proved by the following lines[137]—

चक्षुः शास्त्रं जलं लेख्यं गणितं बुद्धिसत्तमाः ।
पञ्चैते हेतवो ज्ञेया ज्योतिर्गणविचिन्तने ॥

"Eyes, treatises, water (perhaps waterclock and levelling instrument), maps or diagrams (of the earth and sky both) and mathematics or computation and survey (because the term Gaṇita has got very wide connotation) are the five things which are instrumental in the study of stars or heavenly bodies."

The following lines from the Viṣṇudharmottara refer to some sort of mapdrawing or representation of mountains, continents, political divisions and various types of topography, for example, desert, plains and marshy areas[138] :—

यथाभूमिनिवेशास्ते लोकं दृष्ट्वा नरधिप ।
एतद्रूपसमुद्देशमदृष्टानां तवेरितम् ॥
दृष्टं सुसदृशं कार्यं सर्वेषामविशेषतः ।
चित्रे सादृश्यकरणं प्रधानं परिकीर्तितम् ॥
शैलानां शिखरं मूर्ध्नि दर्शयेदनुजोत्तम ।
द्वीपानां च करैः कार्यं तथा भूमण्डलं शुभम् ।
.....तथैव दर्शयेत्.....
भूमिं च जाङ्गलानूपमिश्रां स्वैः स्वैस्तथागुणैः ।

Map of India, Jambudvīpa and the world:

It has already been shown in the Chapter VII that the ancient Indians were fully acquainted with the spape of India, which can be said to be almost accurate. From this it can be inferred with certainty that they must have had the practice and use of drawing maps of India. A reference to actual map of India depicting various rivers, Indraprastha (Delhi) and numerous pilgrim—centres is found in the following lines of the Padma Purāṅa.[139]

137. Vāyu-Purāṇa 52.123. With slight variation, the verse is repeated in the Liṅga Purāṇa also (61.62-63).
138. Tṛtīyakhaṇḍa, 42.47-58.
139. Uttarakhaṇḍa 217. 8-9.

एतद् भारतं खण्डं सपश्यन्ती भूपतिप्रिया ।
यमुनाजाह्नवीमुख्या सरितः समवैक्षत ॥
यमुनातीरगं राजन्निन्द्रप्रस्थमिदं शुभम् ।
ददर्श सा महाभाग तीर्थव्रजयुतं नृप ॥

Perhaps maps of Jambudvīpa were prepared separately, but such references are very rare, and they too appear to incorporate the idea of whole world consisting of all the seven traditional continents. Two such references are quoted below—one is from the Matsya Purāṇa and other from the Bhaviṣya Purāṇa. Here it must be remarked that all the maps of Jambudvīpa and world referred to and discussed henceforth were prepared on sheets of metals generally for the purpose of making gifts to Brāhmaṇas for the ritual धरादान, भूमिदान or ब्रह्माण्डदान.

The Matsya has[140]:—

अथातः संप्रवक्ष्यामि धरादानमनुत्तमम् ।
पापक्षयकरं नृणाममाङ्गल्यविनाशनम् ॥१॥
कारयेत् पृथिवीं हैमीं जम्बुद्वीपानुकारिणीम् ।
मर्यादापर्वतवतीं मध्ये मेरुसमन्विताम् ॥२॥
लोकपालाष्टकोपेतां नववर्षसमन्विताम् ।
नदीनदशतोपेतामन्ते सागरवेष्टिताम् ॥३॥

[This is the reading given by Hemādri (1261 A. D.) in his Caturvargacintāmaṇi—Dānakhaṇḍa—p. 294)—The Matsya Purāṇa of Srīveṇkaṭeśwara Press reads the last line as "नदीनदशतोपेतं सप्तसागरवेष्टितम्".

Its English rendering is as follows, "Now I tell you the method of all-excelling धरादान (making gift of earth), which wipes out sin and all that is inauspicious. One should

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140. Chap. 284, 1 to 3.

Hemādri has given (caturvarg.—Dānakhaṇḍa p. 304) an extract from the Brahmāṇḍa Purāṇa entitled, "जम्बूद्वीपदान-विधि". It also describes the mapping of Jambudvīpa exclusively with its nine varṣas, mountains and other details.

get the earth (replica or diagram or map of it) prepared of gold, having the shape of Jambudvīpa with Maryādā mountains and Meru range in the centre, Lokapālas, nine varṣas, hundreds of rivers and streams and encircled by ocean." But if we take the reading of the last line as given in the Matsya Purāṇa as pointed above, here in the धरादान the depiction of the whole earth (all the seven continents) and the seven oceans are spoken of. Then it may refer to the construction of the map of the whole globe.

Hemādri also has explained it in two ways—firstly saying that here only Jambudvīpa is referred to, secondly generalising it to embrace the whole globe or earth—

"इह हि जम्बूद्वीपसदृशीं कुर्यादित्युक्ते निखिल-नग-नगर-सरोवर-वनाद्यन्वित-मही-सादृश्यप्राप्तौ मर्यादा-पर्वतवतीमित्यादिना तावन्मात्रान्वितधरण्यनुकार इति गम्यते। इतरथा सामान्येनैव तदवगतेविशेषानर्थक्यप्रसङ्गात्, तदयमर्थः हैमीं पृथ्वीं कुर्यादित्युक्ते सप्तद्वीपवत्याः प्रसङ्गे जम्बूद्वीपानुकारिणीमित्युच्यते तत्रापि नाना-पर्वतान्वितानुकारप्रसङ्गे मर्यादापर्वतवतीमिति" तथा सति मेरोरनुकरणप्राप्तौ मध्ये मेरुसमन्वितमिति नानादेवगणानिवृत्त्यर्थं लोकापालाष्टकोपेतामिति, एवं च संख्येयपक्षाश्रयणे पुराणान्तरोपदर्शितवर्षचतुष्टयादिपक्षपरिग्रहणशङ्कानिवृत्त्यर्थं नववर्षसमन्वितमित्युच्यते।"

In the Bhaviṣya Purāṇa[141] also three similar verses occur regarding the preparation of the map of Jambudvīpa, but their diction and the tone have become more ritualistic and sacerdotal and less geographer-like. The second and third verses are at great variance with the Matsya—

लोकपालाष्टकोपेतां ब्रह्मविश्वेशसंयुताम्।
नानापर्वतपूर्णां च रत्नाभरणभूषिताम् ॥९॥
सर्वसस्यविचित्राङ्गीम् ..... ॥१०॥

The differences in the readings of the Bhaviṣya and the Matsya are too obvious to be discussed. Then we take up the expressions "रत्नाभरणभूषिताम्" and "सर्वसस्यविचित्राङ्गीम्". Are we entitled to infer from these two expressions that on the

141. Chap. 165. 8-9-10.

map of Jambudvīpa distribution of gems, minerals and agricultural products were also shown, or would it be a merely far-fetched idea ? It appears from the general tone of the lines that our interpretation is not far-fetched, and that hypothesis of delineation of distribution might hold.

But according to the Brahmāṇḍa and other Purāṇas the dimensions of the Meru and adjoining mountains and other geographic features are very vast.

मेरोस्तु पश्चिमे भागे नवसाहस्रसंमिते ।
चतुस्त्रिंशत्सहस्राणि गन्धमादनपर्वतः ॥
चत्वारिंशत्सहस्राणि परिवृद्धो महीतलात्
सहस्रमवगाहे तु सति द्विगुणविस्तरः ।
पूर्वेण माल्यवान् शैलस्तत्प्रमाणः प्रकीर्तितः

(Quoted by Hemādri, Dānakhaṇḍa, p. 297)

Now to show such vast dimensions as 9,000, 34,000, and 40,000 yojanas on the map is impossible. For this Hemādri says—

अत्र शतसाहस्त्रादियोजनपरिमाणानां पृथिव्यादीनां कर्तुमशक्यत्वात् योजनसहस्त्रस्थाने अर्धाङ्गुलादिमानं परिकल्प्य यथोक्त-संख्यातारतम्यमनुष्ठेयम् । नदीनदशतोपेतमिति, नद्यो भागीरथीप्रभृतिकाः, नदाः शोणादयः, तेषां साकल्येन विधातुमशक्यत्वात् यावच्छक्यमनुकारः कर्तव्यः । अन्ते सागरवेष्टितामिति, यद्यपि यावत्परिमाणा पृथ्वी तावानेव सागरः तथाप्यनुकारमात्रोपदेशात् शक्यानुकारमात्रमाचरणीयम् ।[142]

"Since it is impossible to show extremely large dimensions, for example, one lakh yojanas and so on, of the earth and its other features, it may be assumed that 1000 yojanas are represented by $\frac{1}{2}$ Aṅgula and (similarly) other dimensions can be reduced for easy representation. Again if it is not possible to show all the rivers, like the Gaṅgā and śoṇa only a few important ones which can be possibly shown should be selected. Further though the dimension of the ocean is the same as that of the earth, still the former cannot be shown in totality, so it must be reduced and exhibited as much as is possible."

142. Dānakhaṇḍa, p. 297.

From this it is flagarantly evident that ancient Indians had understood and developed the concept of scale and in this sphere their knowledge, concept and methodology was almost the same as we have today. Now the question may arise as to at what period they reached this advanced stage of development regarding scale and its indispensable uses. Since the above mentioned sacerdotal maps were probably conventionally prepared from the Vedic times or even earlier than that, as has already been shown, the Indian śilpies, citrakāras or cartographers must have been acquainted with scale from that very early period. The Śulvasūtras must have marked a very definite and one of the best epochs of evolution, which has been examined and established in the preceeding pages. Then in the succeeding Paurāṇic age—a few centuries before and after the Christian era this development must have reached another acme. By Hemādri's times all various other things relating to scale must have either improved or become more a matter of course, as is evinced by the above extract from his *magnum opus*. The sequels would further corroborate this inference.

Hemādri gives another very long quotation from the Brahmāṇḍa Purāṇa dealing with making gift of seven continents. In it occurs the following verse—

प्लक्षद्वीपस्य विस्तारः षोडशाङ्गुल इष्यते ।
पादाधिकस्तथान्येषामुत्तरोत्तरमुच्यते ।।

Now the Purāṇas have invariably given the dimension of Plakṣadvīpa to be 2 lakh yojanas. The Brahmāṇḍa Purāṇa says that this should be represented by sixteen Aṅgulas. From this also the concept and use of scale is self-evident.[142a] Again the assertion of the very fact in the Purāṇas that all the continents and oceans can be drawn or represented simultaneously in a convenient and handy from proves the same thing.

142a. But from the following verses quoted in this continuation by Hemādri it appears that in this field perfect accuracy of mathematical computation was not always

In the Padmapurāṇa[143] also there is a reference which informs us of the knowledge of scale where a dimension of 50 crore yojanas was shown—

इत्युक्त्वा भूपत्नी सा दास्या तामुद्धाटयत् ।
मञ्जूषां तत्र संस्थं च पुस्तकं पाणिनाग्रहीत् ।
तत्रावलोकयामास साऽवतारान् समासतः ।
पूर्वं ततस्तु भूगोलं पञ्चाशत्कोटियोजनम् ।'

In the chapter 177 of the Bhaviṣyapurāṇa relating to Brahmāṇḍadāna, the following lines allude to a great reduction of the monstrous size of the Brahmāṇḍa through scale to make the delineation or mapping of the same possible—

तस्याङ्के कल्पयेद् राजन् भुवनानि चतुर्दश ।
वितस्तेरङ्गुलशतं यावदायामविस्तरम् ॥६॥

From the above mentioned chapters of the Purāṇas relating to Dharā or Brahmāṇḍadāna we can gether profuse information on the construction or preparation of world map.

The Liṅga Purāṇa tells[144] us of preparation of world map on a gold sheet having the shape of a quadrilateral and

aimed at and achieved. It was perhaps not so much due to any loophole or imperfection in the concept of scale, rather owing to immense confusion prevailing about the dimensional figures. Lineal, spatial and volume figures were expressed in the same way without any distinguishing denomination or attributive adjunct, for example, in ancient Indian mode of expression, 5 yojanas could imply 5 yojanas, 5 square yojanas or 5 cubic yojanas. It was to be decided by the context. The posterior astronomer—geographer Parameśwara cleary marked this point or flaw of expression. (Cf. Goladīpikā III. 15-16-17).

143. Uttarkhaṅḍa, 217. 4-5.

144. Uttarabhāga 32. 1 to 6 (These verses are quoted by Hemādri also with slight variation in reading).

measuring one cubit (Hasta) on one of its sides. From this it is evident that they not only had the knowledge of scale, but could show the entire earth on a flat quadrilateral just like the Mercator's projection of today. This map delineated the seven continents, seven seas, mountains, pilgrim centres, political divisions and other details.

सुवर्ण मेदिनीदानं प्रवक्ष्यामि समासतः ।
पूर्वोक्तदेशकाले तु कारयेन्मुनिभिः सह ।।
लक्षणेन यथापूर्वं कूपे वा मण्डपेऽथवा ।
मेदिनीं कारयेद्दिव्यां सहस्रेणापि वा पुनः ।।
एकहस्ता प्रकर्तव्या चतुरस्रा सुशोभना ।
सप्तद्वीपसमुद्राद्यैः पर्वतरैभिसंवृता ।।
सर्वतीर्थसमोपेता मध्ये मेरुसमन्विता ।
अथवा मध्यतो द्वीपं नवखण्डं प्रकल्पयेत् ।।
पूर्ववन्निखिलं कृत्वा मण्डले वेदिमध्यतः ।
सप्तभागैकभागेन सह तद्विधिपूर्वकम् ।।

The Skanda Purāṇa[145] traces the old history of preparation of world map and speaks of the delineation of whole earth in a circular from with various abovementioned details including Kulaparvatas, Viṣkambhaparvatas and rivers—

मान्धाता धुन्धुमारश्च हरिश्चन्द्रः पुरूरवा ।
भरतः कार्तवीर्यश्च षडैते चक्रवर्तिनः ।
पृथ्वीदानं पुरा कृत्वा गौतमेश्वरसन्निधौ ।
दत्वा हिरण्मयीं पृथ्वीं सार्वभौमास्ततः स्थिताः ।
भगवत्केन विधिना दातव्या सा वसुन्धरा ।
अहं दास्यामि तां नूनं श्रद्धा मे महती स्थिता ।
भर्तृयज्ञ उवाच –
कार्या पलशतेनोर्वी वृत्ताकारा नृपोत्तमा ।
तदर्धेनाथवा शक्त्या पञ्चविंशतिपलात्मिका ।।
धरादाने महाराज वित्त-शाठ्यं विवर्जयेत् ।
नैवपञ्च पलादर्वाक् प्रदातव्या कथञ्चन ।।

145. Nāgarakhāṇḍa 268. 4 to 13.

लवणेक्षुसुरासर्पिदाधिदुग्धजलोद्भवाः ।
समुद्राः सप्त चैतास्तु कक्षायां तत्र दर्शयेत् ॥
जम्बूप्लक्षकुशक्रौञ्चशाकशाल्मलिपुष्कराः ।
समुद्रान् सरितः सप्त द्वैगुण्येन प्रकल्पयेत् ॥
महेन्द्रो मलयः सह्यो हिमवान् गन्धमादनः ।
विन्ध्यः शृङ्गी च सप्तैव कल्पयेत् कुलपर्वतान् ॥
मध्ये प्रकल्पयेत् मेरुं दिक्षु विष्कम्भपर्वतान् ।
जम्बून्यग्रोधनीपाश्च प्लक्षश्चैव तथा द्रुमान् ॥
गङ्गाद्याः सरितस्तत्र प्राधान्येन प्रकल्पयेत् ।
एवं निर्माय वसुधां सर्वां हेममयीं नृप ॥

Hemādri[146] gives a very long quotation from the Brahmāṇḍa Purāṇa, which provides the best and most detailed description of world map drawing on a flat surface (of the earth) with the use of a scale. So far we have got no better recorded description of ancient Indian cartography than this. It reveals the consummate efflorescence of this art and points that it developed altogether independently according to the indigenous genius. The original Brahmāṇḍa Purāṇa is said to be lost to us,[147] but the extract given by Hemādri must belong to the real old text, because by that time it must have been extant and our great author and Director General of Archives or minister of Yādava kings of Devagiri must have had easy access to it or possessed it. The quotation of Hemādri, therefore, may most probably relate to a period near about the beginning of the Christian era or prior to that and portrays the condition of Indian Cartography of that period. Concurrent evidences of the Jain and Buddhist cartography testify to the same thing.

Here the whole cartography was done on a neat level surface of the earth prepared specifically for the purpose. It depicted the seven oceans, rivers, flora and fauna of each division. The verses are[148]—

146. Caturvargacintāmaṇi, Dānakhaṇḍa, p. 313.
147. Winternitz, Vol. I, p. 578.
148. Caturvargacintāmaṇi—Dānakhaṇḍa, p. 313.

सप्तद्वीप-दानविधि (ब्रह्माण्ड पुराण)

ब्रह्मा उवाच—

श्रृणु देवमुने दानं सप्तद्वीपाह्वयञ्च तत् ।
तत्कृत्वा पृथिवीदानफलं सर्वमुपाश्नुते ।।
पुण्यकालेषु सर्वषु चन्द्रसूर्यग्रहादिषु ।
देवागारादिदेशेषु पुण्येष्वायतनेषु च ।।
विप्रं गुरुवेदविदञ्च दक्षं विद्याप्रदं वृणुयात्तत्र पूर्वम् ।
स कारयेच्छैवतदङ्गकार्यमृते दानं गुरुणानेन सर्वम् ।
सभाभूमिं लिम्पयेद् गोमयेन सवारिणा शुचि तत्रापि मध्ये ।
कृत्वा द्वीपं जम्बु-संज्ञं यथावत् तद्वाह्ये च प्लक्षनामा निबद्धः ।
जम्बुप्लक्षाह्वयौ द्वीपौ शाल्मलश्च तथापरः ।
कुशः क्रौञ्चश्च शाकश्च पुष्करैश्च सप्तमः ।।
एते द्वीपाः समुद्रैश्च सप्त सप्तभिरावृताः ।
लवणेक्षु-सुरा-सर्पि-दधि-दुग्ध-जलैः समम् ।।
जम्बूद्वीपः समस्तानामेतेषां मध्यमः स्मृतः ।
तस्यापि मेरुर्द्वे वर्षे मध्ये कनकपर्वतः ।।
प्लक्षद्वीपस्य विस्तारः षोडशाङ्गुल इष्यते ।
पादाधिकस्तथान्येषामुत्तरोत्तरमुच्यते ।।
षोडशद्रोणधान्यैश्च प्लक्षद्वीपं प्रकल्पयेत् ।
ततः पादाधिकं प्रोक्तं मेदिन्यामुत्तमोत्तमम् ।।
विस्तार एवं द्वीपानामुदधीनाञ्च सर्वशः ।
प्लक्षपञ्चद्वीपेषु वर्षभूधर-निम्नगाः ।।
प्रत्येकं सप्त सप्त स्युः श्वेत-तण्डुल-निर्मिताः ।
पुष्करे भूधरं त्वेकं मध्यतो वलयाकृतिम् ।।
वर्षद्वयं तथा चान्यन्नामतः श्रूयतां मुनेः ।
प्लक्षे शान्तमयं वर्षं शिखरं सुखदं तथा ।।
आनन्दं च शिवं चैव क्षेमकृत् सुखमेव च ।
गोमेदपर्वतश्चान्द्रो नारदो दुन्दुभिस्तथा ।।
सोमकः सुमनाश्चैव वैभ्राजः सप्तपर्वताः ।
अनुतप्ता शिवा चापि अम्बिका त्रिदवीक्रमात् ।।
अमृता सुकृता चैव सप्तैतास्तत्र निम्नगाः ।
प्लक्षन्तु प्रथमे वर्षे मध्ये विनिवेशयेत् ।।

पलेन वा यथाशक्ति तदर्धेन विनिर्मितम् ।
तत्पार्श्वे देवदेवेशं सर्वलोकगुरुं हरिम् ।।
सोमरूपधरं देवं सौवर्णं विनिवेशयेत् ।
श्वेतो हरित-जीमूतौ रोहितो वैद्युतस्तथा ।।
नर्मदः सुप्रभः सप्तवर्षाण्येते च पर्वताः ।
कुमुदश्चोदनश्चैव तृतीयश्च बलाहकः ।।
कङ्कश्च महिषश्चैव कुकुद्मान् सप्तमो गिरिः ।
योनिस्तोया वितृष्णा च चन्दा शुक्ला च मोचनी ।।
विवृतिः सप्त नद्यश्च शाल्मले परिकीर्तिताः ।
उद्भिदो वेणुमांश्चैव सुरतो लवणो धृतिः ।।
प्रभाकरश्च कपिलः पर्वतान् शृणु नारद ।
मणिद्रुमो हैमशैलो द्युतिमान् पुष्पवांस्तथा ।।
कुशोधमश्च हरितो मन्दरः सप्तमस्तदा ।
धूतपापा शिवा चापि पवित्रा शमिता तथा ।।
विद्युदम्भा महिषी चैव सर्वपापहरा तथा ।
कुशस्तम्बं कुशद्वीपे क्रौञ्चे चैतन्निबोध मे ।।
वर्षाणि भूधराश्चैव विष्णुश्च पर एव च ।
अन्धकार मुनिश्चैव दुन्दुभिः सप्तमस्तथा ।।
क्रौञ्चश्च वामनश्चैव अन्धकारोऽथ पञ्चमः ।
पुण्डरीको दून्दुभिश्च सप्तैते स्युरिहाचलाः ।।
गौरी कुमारी सन्ध्या च रात्रिश्चैव मनोजवा ।
यक्षादिः पुण्डरीकश्च सप्त सप्त उदाहृताः ।।
शाकमध्ये शाकवृक्षो वर्षप्लक्षे च निम्नगाः ।
सप्त सप्त च देवर्षे श्रूयतां गदतोत्र मम ।।
जलदश्च कुमारश्च सुकुमारो मणीचकः ।
कुसुमोत्तम मोदश्च सप्तमश्च महाद्रुमः ।।
उदयो जलधारश्च रैवतश्चानुपर्वताः ।
पञ्चमोऽभ्रगिरिः शैलोऽम्बिका केसरी तथा ।।
सुकुमारी कुमारी च नलिनी वेणुका तथा ।
इन्दुका रेणुका चैव गभस्तिः सप्तमी तथा ।।
पुष्करे तु महापद्मो धातकीतिः प्रकीर्तिता ।
मध्यतो वलयाकारो मानसोऽत्र च पर्वतः ।।

न्यग्रोधवृक्षः पूर्वे तु ब्रह्मणः स्थानमुच्यते ।
सप्तमः पुष्करद्वीपः तद्वदेवसमावृतः ॥
एवं द्वीपाः समुद्रैश्च सप्त सप्तभिरावृताः ।
द्वीपैश्चैव समुद्रैश्च समाना द्विगुणाः परे ॥
द्वीपमानान् द्रुमान् सर्वान् राजतान् विनिवेशयेत् ।
तथा पक्षिमृगान् मत्स्यान् पर्वतोदधिषु क्षिपेत् ॥
जम्बूद्वीपाधिपं विष्णुं तत्र चेव निवेशयेत् ।[149]

But it should not be understood that world maps were prepared or drawn only for sacerdotal or ritualistic purposes. World maps prepared for geographical, astronomical and oceanographic or navigational purposes were also quite common and used copiously. The proof of all this would be cited and dissected gradually hereafter.

World maps were drawn for other than sacerdotal purposes is evidenced by the following quotation from the Padma Purāṇa.[150] It also reveals that these maps were prepared and maintained in book form and kept with care and safety in chests, and this practice appears to have been in vogue prior to Ptolemy (150 A.D.). It is clear from this that ancient Indians prepared Atlases also.

श्रीनारद उवाच—

इत्युक्ता सा कला राजंस्तथा नृपतिभार्यया ।
स्वकोशात्स्वर्णमञ्जूषामानय्य विदधे पुरः ॥
उवाच च महाराजभार्येऽस्यां महदद्भुतम् ।
पुस्तकं वर्तते देवि तत्र चित्राणि सन्ति वै ॥
उद्घाटय दृश्यतां किञ्चित्किं किमस्त्यत्र पुस्तके ।
रंस्यते ते मनो नूनं तत्रास्थालेख्यदर्शने ॥
इत्युक्ता भूपपत्नीसा दास्या तामुदघाटयत् ।
मञ्जूषां तत्र संस्थं च पुस्तकं पाणिनाऽग्रहीत् ॥
तत्रावलोकयामास साऽवतारान्समासतः ।
पूर्वं ततस्तु भूगोलं पञ्चाशत्कोटियोजनम् ॥

149. The Viṣnu Dharmottara Purāṇa (Khaṇḍa III) also speaks of preparation of the world map—vide 159. 5.
150. Uttarakhaṇḍa 217.1 to 9.

तत्रान्धकारसंयुक्ता भूमिर्दृष्टा च काञ्चनी ।
एतयोरन्तरे राजंल्लोकालोकश्च पर्वतः ।।
सप्तद्वीपास्ततो दृष्टाः समुदैः सप्तभिर्वृताः ।
एतेषु नद्यः शैलाश्च खण्डानि तु महामते ।।
एतद्भारतखण्डं सा पश्यन्ती भूपतिप्रिया ।
यमुनाजाह्नवीमुख्याः सरितः समवैक्षत ।।
यमुनातीरगं राजन्निन्द्रप्रस्थमिदं शुभम् ।
ददर्श सा महाभाग तीर्थव्रजयुतं नृप ।।

In the Bhaviṣya Purāṇa[151] we read not only about cartography of the world map, but about the delineation of the fourteen Bhuvanas also, which, of course, included our world as well. This Bhuvana map was prepared on a square piece of cloth, which had a side measuring nearly eleven feet. Thus it totally resembled a large-sized wall map of today. The verses are :—

सप्तहस्तं पटं कृत्वा चतुरस्त्रं सुसंहतम् ।
अभिन्नाङ्गं दृढं शुद्धं शुद्धस्फटिकवर्चसम् ।।
तस्मिन् सर्वाणि राजेन्द्र भुवनानि च लेखयेत् ।
चातुर्वर्ण्यकमानीय विचित्रं चित्रकर्मणि ।।
युवानं व्याधिरहितं भव्यं चित्रकरं शुभम् ।
संपूजयित्वा यत्नेन दिव्यवासो विभूषणैः ।।
तस्मिन् कर्मणि युञ्जीत पठ्यमानैर्द्विजोत्तमैः ।
शङ्खभेरीनिनादैश्च गीतमङ्गलनिस्वनैः ।।
पुण्याहजयघोषैश्च ब्राह्मणान्पूजयेत्ततः ।
आचार्यमपि संपूज्य वासोभिर्भूषणैस्तथा ।।
प्रारंभं कारयेद्राजतत्पटे तस्मिन्यथोदितम् ।
मध्ये च लेखयेद् राजाञ्जम्बूद्वीपं सविस्तरम् ।।
तस्य मध्ये स्थितो मेरुर्मेरोरुपरि देवताः ।
दिशासु लोकपात्लानां पुरोष्टौ सुरसंयुताः ।।
सप्तद्वीपवती पृथ्वी सप्त चैव कुलाचलाः ।
सागराः सप्त चात्रैव नद्यो ह्रदा सरांसि च ।।

151. 191.7 to 24 (designated as Bhuvanapratiṣṭhā).

पाताला: सप्त चात्रैव सप्तसर्गविभूतय: ।
ब्रह्मविष्णुशिवादीनां भुवनानि यथाक्रमम् ॥
ध्रुवमार्गस्तथादित्यो ग्रहतारागणैर्युत: ।
देव-दानव-गन्धर्वा यक्षराक्षसपन्नगा: ॥
ऋषयो मुनयो गावो देवमातर एच च ।
सुपर्णाद्याश्च विहगा नगाश्चैरावतादय: ॥
दिग्गजाष्टकमत्रैव लेखयेन्मदमण्डितम् ।
एवंविधं राजन् कारयित्वा सुशोभनम् ॥
दशोत्तरेण पयसा एतत्सर्वं समावृतम् ।
तत्तेजसावृतं भूयो महताग्रेण सर्वत: ॥
तेजस्तद्वायुना वायुराकाशेन समावृत: ।
भूतादिना तथाकाशं भूतादिर्महता तथा ॥
अव्यक्तेन महांश्चैव व्याप्तो वै शुद्धिलक्षण: ।
अव्यक्तं तमसा व्याप्तं तमश्च रजसा तथा ॥
रज: सत्त्वेन संव्याप्तं त्रिधा प्रकृतिरुच्यते ।
एवमावरणोपेतं ब्रह्माण्डमखिलं नृपं ॥
पुरुषेणावृतं सर्वं सबाह्याभ्यन्तरं तथा ।
एतत्सर्वं पटस्थं तु कृत्वा चित्रमयं सुधि ॥
....

For another through and through ritualistic and sacerdotal purpose the map of the whole universe was constructed in the shape of two hemispheres aspiring to be true to scale and jointed together. The ceremony was called Brahmāṇḍadāna and the preparation of the metallic map is described thus.[152]

..... ।
ब्रह्माण्डं काञ्चनं कृत्वा सर्वलक्षणसंयुतम् ॥
देवासुरमनुष्यैश्च गन्धर्वोरगराक्षसै: ।
संयुक्तं च नदीभिश्च समुद्रै: पर्वतैस्तथा ॥
विमानशतकोटीभिर्भूषितं चाप्सरोवरै: ।
दिग्गजासंयुक्तं मध्यस्थितचतुर्मुखम् ॥
शिवाच्युतार्कशिखरमुमालक्ष्मीसमन्वितम् ।
तस्याङ्के कल्पयेद् राजन् भुवनानि चतुर्दश ॥

152. Bhaviṣya Purāṇa. 177.3-8.

वितस्तेरङ्गुलशतं यावदायामविस्तरं ।
कुर्याद्विंशत्पलादूर्ध्वमासहस्राच्च भक्तितः ॥
शकलद्वयसंयुक्तं पुटाकारसुसंहितम् ।
शिल्पिना यस्माद् ब्रह्माण्डं सर्वकामदम् ॥

F. Wilford[153] says that he had seen world and various other maps prepared according to the Paurāṇics and Indian astronomers. There appears to be little doubt that these maps must have been in vogue from very ancient times, that is, at least, from the beginning of Christian era, as the various citations above concurrently prove. The present author also has seen two or three hundred years old numerous world and other maps in Manuscript libraries and private collections, and actually possesses one or two. Here Wilford's selected plates of such maps and the photographs of some others procured by the present researcher have been reproduced and their details furnished in the chapter VII.

That ancient Indians prepared quite accurate and indispensable navigational maps is evidenced by Vṛhatkathāślokasaṅgraha[154] of Buddhaswāmī (500 or 600 A.D.). In it we read, "In course of his voyage, Manohar explored and determined the geographic position of Sṛṅgavan mountain and the city of Śrīkuñjanagara and then put it down on his map (सहसागरदिग्देशं स्पष्टं संपुटकेऽलिखन्).[155] Here the term "संपुटक" implies "folded map" or "Atlas".

The Encyclopaedia Britannica further fortifies that the Dravidas and Gujarātis were very expert in preparing sea-maps, coastline maps and other navigational charts. And that these maps were prepared before Ptolemy (150 A.D.) and he actually used them in his works. In the extract given below there occurs a Sanskrit word "Zam" (याम) meaning

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153. Asiatic Researches, Vol. VIII, p. 270-1, Vol. X, p. 140
154. Ed. and Trans. F. Lacôte. vide "Sārthavāha" by Dr. Motichandra p. 146.
155. Vṛhatkathāślokasaṅgraha 19.107.

'a part of the day' which undoubtedly indicates that the ancient Indians were pioneer in the field and other adjoining sea-faring nations copied a lot from them.[156] The recognition of the importance of Ujjain further bolsters up the assertion. The Encyclopaedia Britannica has:—

"The charts in use by the medieval navigators of the Indian ocean—Arab, Persians or Dravidas—were in equal in value if not superior to the charts of the mediterranean. Marco Polo (1292) mentions such charts; Vasco Da Gama (1498) found them in the hands of his Indian pilot, and their value is fully explained in the Mohit or encyclopaedia of the sea compiled from ancient sources by the Turkish Admiral Sidi Ali Ben Hossein in 1554. These charts are covered with a close net work of lines intersecting each other at right angles. The horizontal lines are the parallels, depending upon the altitude of the pole star, the calves, the little Bear and the Barrow of the Great Bear above the horizon. This altitude was expressed in "isbas" or inches cach equivalent to 1°4′ 50″. Each isba was divided into "Zams" or eights. The interval between the parallels thus only amounted to 12′51″. These intervals were mistaken by the Portugese occasionally for degrees, which account for Malacca, which is, in latitude 2°13′ N, being placed on Contino's chart (1502) in lat. 14′ S. It may have been a map of this kind which accounts for Ptolemy's moderate exaggerations of the size of Taprobana (Ceylon). A first meridian, separating a leeward from a windward region, passed through Ras Kumari (Camorin) and was thus nearly identical with the first meridian of the Indian astronomer which passed through the sacred city of Ujjain (Ozene of Ptolemy) or the meridians of Azin of the Arabs. Additional meridians were drawn at intervals of Zams, supposed to be equal to three hours sail". [157].

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156. It is further corroborated by an anterior page 31 of the chapter II of the present work. (Eight watches)

157. Encyclopaedia Britannica, vol. 14, p. 841.

It is further stated that in 1498 Vasco Da Gama saw a chart of Coast line which was shown to him by a Gujarati.[158].

From the above extract it is obvious that ancient Indians were fully acquainted with the concept, elaborate and scientific methodology and utilization value of map-projection and its cartography much anterior to Ptolemy. The oldest prime meridian of Ujjain is the clearest proof of this. They prepared graticules—parallels or latitudes and longitudes with exceptional dexterity and accuracy ; at least it is true considering the great antiquity. The discussion based on astronomical works in the sequel, would further pile up evidences to testify this.

Perhaps the Kathāsaritsāgara of Somadeva Bhatta (1070 A. D.) also points to the drawing of world-map, as it says—

"I will sketch for you the whole world, gods, Asuras, and men, in case you may be able to recognise him ; and point him out to me among them, and when Uṣā answered, "By all means". She painted for her with coloured pencils the whole world in order. Thereupon Uṣā exclaimed joyfully. "There he is, and pointed out with trembling finger Aniruddha in Dwārāvati of the race of Yadu".[159].

Astronomical works :

Globe plays very important role in modern geography. Ancient Indians had realised its necessity and utility full well, and they had developed the practice of constructing globe to represent the earth and simultaneously used the concept of heavenly globe to make the combined study of geography and astronomy together with their mutual impact and relationship. The chapter XIII of the Sūryasiddhānta (379 or 500 A. D.) tells us that this globe was constructed of wood and the concept of heavenly globe was concretely realised

158. Ibid, Vol. 21, p. 609,
159. 6. 5. 18-19 (text) ; Eng. Trans, Tawney Vol. II

and used by showing heavenly graticules around the wooden globe of the earth. Other treatises inform that the heavenly graticules (horizontal circle, equatorial circles and others) were made of tender bamboo sticks. In the earthly globe north-pole was kept upwards and south-pole downwards. The slokas are[160]—

भूगोलकस्य रचनां कुर्यादाश्चर्यकारिणीम् ।
अभीष्टं पृथ्वीगोलं कारयित्वा तु दारवम् ॥
दण्डं तन्मध्यगं मेरोरुभयत्र विनिर्गतम् ।
आधारकक्ष्माद्वितयं कक्ष्यां वैषुवतीं तथा ॥

Āryabhaṭṭa refers to the construction of the globe representing the earth in the Golapāda of his Āryabhaṭīya.[161] Brahmagupta also speaks of the preparation of earthly globe.[162]

Since all the astronomers (Āryabhaṭṭa, Varāhamihira, Bhāskarācārya and others) knew that continents, oceans, and other features existed on this globe, they must have devised the method of showing these on the globe in the form of map drawn on it. The Brahmasiddhānta[163] (Śākalyokta) furnishes more explicit information on this point. It says that globe was prepared and contients, mountains, oceans, rivers, towns and various other facts were exhibited on it.

तथैव घटिकाष्टया ते यत्सर्वं यथोदितम्
दारुभिर्विषुवत् कक्षा क्रान्तिकक्षा उभेऽपि च ॥ २१५ ॥
आधारकक्षा क्षितिजं मण्डलं चक्रकैः समाः ।
राश्यंशकक्षाः षट्तिस्र उदक् तिस्रस्त्वपागतीः ॥ २१६ ॥
कृत्वा तद्वद्दिनवासदलैर्बद्धा यथोचितम् ।
आधारकक्षयोर्योगो ध्रुवयोः स्थानमत्र नु ॥ २१७ ॥
रथचक्रविले मेहदण्डद्वीपाद्रिसागरैः ।
नदीभिः पत्तनपुरैर्भूगोलेन युतेन च ॥ २१८ ॥

160. XIII. 3-4. (Sūryasiddhānta).
161. Verse 22-23.
162. Brahmasphuṭasiddhānta chapter 21.
163. II. 214-221.

क्रान्तिकक्षाश्चतुःषष्टिस्ततो वृत्तेन सर्वतः ।
मध्योन्नतं प्रसार्याग्रे उभयत्र विनिर्गते ।। २१९ ।।
यथाध्रुवौ ध्रुवसमौ स्तम्भयोः स्थापयेद् ध्रुवम् ।
कक्षाभिर्मध्यकक्षाद्यैर्ध्रुवद्वयगतैरपि ।। २२० ।।
विभज्य गोलं द्वादशधा मेषादीन् निर्दिशेत् समान् ।
तुलादिमेषादितः कर्कमृगादि च लवद्वयोः ।। २२१ ।।

By the time of Bhāskarācārya (1150 A. D.) the art of preparation of globe and doing of requisite cartography on it for everyday purposes appear to have reached their zenith marking out the most brilliant acme of originality of Hindu Geography. Verse 23 of the Tripraśṇavāsanā[164] unambiguously informs us that globe was used for illustration in teaching students (गोलं भ्रामयन् प्रदर्शयेत् सर्वम्—Everything should be illustrated with the help of the globe).

In the preceding section of this chapter it has been shown that ancient Indian Āryans were fully acquainted with the drawing of graticules or longitude and latitude on their maps from great antiquity—even earlier than the beginning of the Christian era. Old astronomical treatises further confirm it.

The Sūryasiddhānta firstly speaks of[165] preparation of three heavenly circles—equatorial and two base ones and then directs to divide each of these in 360° parts. Thus it is obvious that those people knew to prepare heavenly graticules. The golabandhādhikāra of the Siddhāntaśiromaṇi states the same fact.

The drawing of graticules on the earthly globe or flat surface is still easier and was always practised. The Indians must have known longitude and latitude and their cartography near about two or three centuries before Christ or even earlier than that for the preparation of oceanographic charts or maps. Even the oldest scriptures[166] and the

164. Golādhyāya
165. XIII. 4-5-6.
166. E. G. Vedāṅgajyotiṣa (Cf. Bhāratīya Jyotiṣa-S. B. Dīkṣita, p. 205). From S. B. Dīkṣita it appears that Vedāṅgajyotiṣa had a conception of meredian also.

Purāṇas knew of the equator and the latter had known meridians, as they have said that sunrise, sunset, midday and midnight come simultaneously at four different towns of the globe separated by 90° of longitude. Similar information is furnished by the Abhidharmakośa[166a] which is based on Lokaprajñapti written about 500 B. C., which shows that those Buddhists, much before Christ or at least round about 500 B. C. possessed the concept of meridians and must have utilised it at least for navigational purposes. So longitude and latitude drawing must have been developed by the Indians at least half a millineum before Christ.

When it is conceded that ancient Indians knew preparation of some sort of graticules for heavenly sphere and were acquainted with latitude and longitude, it can be easily and unhesitatingly inferred that they must have had evolved some sorts of projection also. It is unfortunate that in none of the early astronomical works is furnished some accurate knowledge or nomenclature regarding this branch of cartography. But it is definite that a generic name 'परिलेख' was used for denoting every kind of cartography, and this must have included the drawing of projections also. In the astronomical treatises, however, perhaps due to extreme necessity, a particular kind of projection is discussed. It is meant for the study of eclipses and is styled as 'छेद्यक'. The Sūryasiddhānta defines the term 'छेद्यक' thus, "Without the knowledge of छेद्यक परिलेख or diagram, accurate study of eclipses of the sun and moon, their beginning and end and various computations regarding the shadowing of the parts cannot be made. Now, therefore, I am explaining the cartography of the projection (छेद्यक) for all this."[167]

The Brahmasphuṭasiddhānta defines the छेद्यक or projection in the following way, "येन क्षेत्ररचनया ग्रहणादिकं प्रदर्श्यते स छेद्यक इति". The cartography which is used to show eclipses

166a. III. 60.

167. Parilekhādhikāra, verse I or VI. I.

and the like is termed as projection (छेद्यक)". From this (the specific use of the word आदिकं) it is clear that छेद्यक or projections were prepared for other geographical or astronomical purposes also. Thus modern types of projections would also have been known and used.[167a]

Since the latter types of projections had great utilitarian or practical value for the administrative, navigational and military purposes, they would not have been explained in treatise publicly and popularly and, were ever kept secret. On this point the Sūryasiddhānta says, "The art of cartography is secret of Gods. This knowledge cannot be imparted to every individual. It should be given only a tested pupil who has spent a year or two in learning astronomy. This is the reason why I am not making the knowledge of cartography public to the readers."[168]

Some instruments : (cf. Fig 27)

Brahmagupta has described a special type of instrument known as यष्टियंत्र, in which a long stick and a straight vertical bamboo pole were used. By this a standing observer taking the sight of a star through the collinearity of the two extremities of the stick and the star could measure the altitudinal or vertical angle of the latter. With this instrument the pole star latitude was also determined.[169] This instrument, therefore, can be christened as the ancestor of modern sextant.

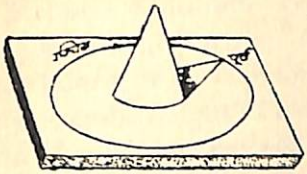
Verse 27 of the same chapter gives the method of determining quarters from the yaṣṭi-yantra ; by knowing quarters, the angular distances in the horizontal plane could also be found out by computation, thus no wonder yaṣṭiyantra might have been serving the purpose of theodolite also occasionally.

167a. From verses 68-59-60-61 of the Bhuvankośa together with chapters on Jyotpatti in the Siddhāntasiromaṇi, it appears that Bhāskarācārya must have known various types of map-projections.

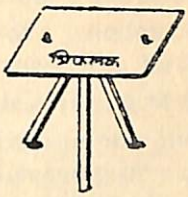
168. VI. 24.

169. 22.25 to 29.

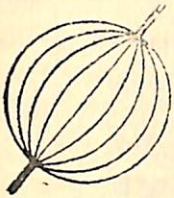
Fig. 28



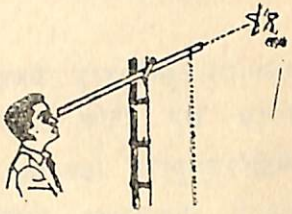
Gnomon (first introduced before the beginning of the Christian era) for determining compass directions.



Survey Plane-Table—a thousand years ago.

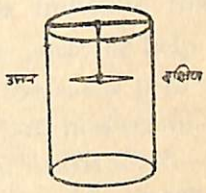


Atleast 1500 years old globe for representation of the heavens and the earth.



Brahmagupta's Yaṣṭi Yantra or Bhāskarācārya's Dhīyantra which stands at the top of the pedigree of modern Theodolite and sextant.

Ancestor of Spirit Level-Pristine Levelling instrument.



The unsophisticated embryo of Prismatic compass which took ages to perfect into its modern complicated configuration.

To face P. 256

Fig. 20

Bhāskarācārya has named this instrument as धीयन्त्र. and applauded it vociferously[170].

Śrīpati's Siddhānta-Śekhara describes a particular instrument known as त्रिफलक. It was made of a wooden horizontal plane board or surface and stood on three legs having nearly three-fourths height of a man. The description of the instrument shows that त्रिफलक was some instrument just like the modern plane-table used in modern surveying or was actually the "plane-table" of that time. Though according to Śrīpati it was used to determine the height of the pole star and thereby for finding the latitude and co-latitude of place, it is just possible that it might have been used for geographical observation or surveying also. The verses read:—[171]

अम्भोभिः सुसमीकृते त्रिफलके दृष्टयुच्छ्रिते स्थापयेत् ।
शङ्कुं तत्परिमाणमुत्तरदिशं कोटीं दृशं तत्तले ॥
शङ्कुव्रग्रे भवति ध्रुवे यदि तदा मेरावुदक्कोटिके ।
लङ्कायां वसतिस्ततोऽन्यविषये तच्छङ्कुना भेदयेत् ॥

शङ्कुव्रग्रतो यत्र च सूत्रपातः
स्तच्छङ्कु-मूलान्तरमत्र लम्बः
शङ्कुव्रग्र भूम्यन्तरमक्षउक्त
स्त्रिज्याग्रतस्तौ भवतोऽनुपातात् ।

Here in the first line of the first verse there occurs the expression "अम्भोभिः सुसमीकृते". This indicates that Śrīpatī knew the levelling of the instrument with the help of water, performed in the same way and on the same principal as we do in modern times for the levelling of plane-table or other survey instruments with the help of spirit level. The commentator of the Siddhāntaśekhara, "अम्भोभिः सुसमीकृते वारंवारं जलस्याभितः समप्रसारणद्वारा-सुसमीकृते" which simply corroborates the foregoing averment".

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170. 12.40 (Yantrādhyāya)
171. IV. 122.123.

Knowledge of concept of levelling of very ancient Indians has already been discussed. It is certain that they knew the levelling of the ground[172] and various types of astronomical and geographical apparatus with the help of water and other instruments.

Āryabhaṭīya describes the determination of level of any plot of ground with water.[173] Brahmagupta and Lalla also knew it. The former says, सलिलेन समं साध्यं"[174]. The later states, "लम्बको भ्रमः सलि लं स्यु यन्त्रसाधनानि प्रज्ञा च"[175]. "Levelling can be performed through plumb, a pair of compasses (or some other instrument ?) and water."

Commenting on the aforesaid verse of Āryabhaṭīya, Parameśvara (1365-1460 A.D.) says "After making the selected plot even, according to the line of sight, draw a circle (covering a plot). Another circle should be drawn (from the same centre) with a radius two or three Aṅgulas longer than the former. Digging the earth out of the two circumferences of a circular channel should be constructed and filled with water. Water surface coinciding in each point with surfaces of the earth within the inner circle, indicates the level of the surface of the plot. Depression or elevation in water level indicate the elevation or depression in earth surface respectively."

It can be observed with certainty that in road making and architectural works some sort of levelling instrument must have been used.

Architectural Sources :

On the authority of various architectural treatises, for example, Mānasāra, Mayamatam, Samarāṅgaṇasūtradhāra and Aparājitapṛcchā, it can be remarked that this branch of one of the most essential sciences contributed tremendously

172. Vide p. 260, Journal of G. N. Jhā Research Institute, Allahabad, Vol. IV, 1947, parts 3-4.

173. Gaṇitapāda, Verse 13. "साध्याजलेन समभूरध उर्ध्वं लम्बकेनैव"

174. Chapter 22.7

175. Yantrādhyāya, verse 54.

to the development of survey and cartography in India from the hoariest early days.

The description of various technicians who worked in this field would amply clarify this statement. The Mānasāra says, "Maya's son is known as Sūtragrāhi (draftsman).[176] The son of the sage Tvaṣṭṛ is called Vārdhaki (designer).[177] The Sthapati knows all the śāstras (branches of knowledge). The Vārdhaki is well-versed in the work of measurement.[178]... The sūtragrāhī also knows the Vedic literature, is well-versed in the śāstras and is an expert in architectural drawing."[179]

The Mayamatam furnishes[180] more succinct accoant with better perspicuity, "The Sthapati, among his many other

176 II.18 (line). Eng. trans. P. K. Acharya.

177 II.19 (line).

178 II.24-25 (lines).

179 II.32 (line).

180 Purport of Chapter V, verses 15 to 22 (given in Town-planning in ancient India by B. B. Dutta, pp. 167-9) which run as follows:—

स्थपतिः स्थापनार्हः स्यात्-सर्वशास्त्रविशारदः ।
नहीनाङ्गोऽतिरिक्ताङ्गो धार्मिकस्तु दयापरः ।
अमात्सर्योऽनसूयश्चातन्द्रितस्तभिजातवान् ।
गणितज्ञः पुराणज्ञः सत्यवादी जितेन्द्रियः ।
चित्रज्ञः सर्वदेशज्ञश्चान्नदश्चाप्यलुब्धकः ।
अरोगी चाप्रमादी च सप्तव्यसनवर्जितः ।
सुनामा दृढबुद्धिश्च वास्तुविद्याब्धिपारगः ।
स्थपतेस्तस्य शिष्यो वा सूत्रग्राही सुतोऽथवा ।
स्थपत्याज्ञानुसारी च सर्वकर्मविशारदः ।
सूत्रदण्डप्रपातज्ञो मानोन्मानप्रमाणवित् ।
शैलदार्विष्टकादिनां सूत्रग्राहिवशात्तुयः ।
तक्षणात् स्थूलसूक्ष्माणां तक्षकः स तु कीर्तितः ।
मृत्कर्मज्ञो गुणी शक्तः सर्वकर्मस्वतन्त्रकः ।
तक्षकस्तक्षणेनास्मिन्नुपर्युपरि युक्तितः ।
वृद्धिकृद् वार्धकिः प्रोक्तः सूत्रग्राह्यनुगः सदा ।
कर्मिणो निपुणाः शुद्धा बलवन्तो दयापराः ।

qualifications, must be endowed with ability to plant a town or an edifice (स्थापनार्हः), knowledge of surveying (गणितज्ञः), skill in draftsmanship (चित्रज्ञः), capability for reconnoitering localities (सर्वदेशज्ञः), mastery over the entire science of architecture and town-planning (वास्तुविद्याब्धिपारगः), and he should be well-versed in the holy scriptures and the Purāṇas. His attributes indicate beyond doubt that the town-planner or the Sthapati, coming as he did from a noble family, by his birth and literary attainment, was quite familiar with the cultural ideas and predilections, religious and social, of the people for whom he had to build the city..... Further it seems very probable that he had to prepare carefully a chart marking in it the boundaries, the roads, and scheme of their planning and the location of public buildings, tanks, and gardens. Next in the rank to the Sthapati was the Sūtragrāhī (literally lineman or plumber) expert in surveying and draftsmanship (रेखज्ञः). He was either the son or the disciple of the Sthapati, strictly obedient to the latter. He was the superior officer (गुरु), over the following two. The Takṣaka, the Chiseller, well-versed in all mechanical arts including carpentary, was the officer subordinate to the Sūtragrāhī. Under the Takṣaka was placed the वार्धकि, the joiner, who was a specialist in draftsmanship and the perspective and was an adept in joining works of all sorts.''

Referring to the planning of towns (literally villages) the Mānasāra enumerates[181] eight types of maps or shapes of towns – Daṇḍaka (Rectangular), Sarvatobhadra (square), Nandyā-varta (rectangular), Padmaka (circular, quadrangular, hexagonal or octogonal), Swastika (of the shape of Swastika), Prastar (square), Kārmuka (bow-shapped), and Caturmukha (square).

The Mayamatam also speaks of[182] eight classes of plans of towns with a little variation in names and details; Daṇḍaka,

181 IX.5-8 (lines).

182. IX. 33-34, for details Cf the following verses.

Swastika, Prastara, Prakīrṇaka, Nandyāvarta, Parāga, Padma and Śrīpratiṣṭhita.

After selection of the site, the whole of it was divided into a large number of square chambers. Due to the employment of various methods of division, this procedure gave a large variety of charts, maps, or figures of detailed plan. The chapter VII of the Mānasāra has recognised thirty two types of such detailed plans or figures with numbered chambers. They bore the names Sakalapiṭha, Sthaṇḍila, Paramaśayika, Triyuta and so on. Thus originated thirty-two types of Vāstupada or town-maps, building maps or palace maps. On this basis these plans (रेखाचित्र) the whole architectural work was carried on.

In this connection it is notable that we have not got merely verbal descriptions of this maps, but possess actual specimens of such cartography, Vṛahatsanhitā commented by Bhattotpala (966 A. D.) contains[183] a large number of such plans or architectural maps which were drawn by the commentator himself; this is proved by the fact that Bhattotpala himself writes in the commentary[184] "एवमेते सर्व एव स्वल्पधियां विन्यासेन द्वितीयपत्रे प्रदर्श्यन्ते", "These are all being shown on the plan of map on the next leaf.....", and "एषां विन्यासः सुगमत्वान्न प्रदर्शितः।" "The maps of these, being easy, have not been shown".[185]

The whole procedure of ground surveying, planning and measurement has been called 'भूमिति' by the Mayamatam[186]

एवं प्रोक्ता भूमितिर्देवतानां
वर्णानां चाप्यत्र जात्यन्तराणाम् ।
ग्रामादीनां मानविन्यासमार्गः
सालङ्कारं चारु संक्षिप्य तन्त्रात् ।।

183. These can be found in the Vṛhatsanhitā edited by Pt. Sudhakara Dvivedi.
184. Commentary on 52-56.
185. Ibid. 52.38.
186. IX. 129.

The Samarāṅgaṇasūtradhāra informs us that very elaborate survey of regions with every type of land utilisation was practised in the time of Bhoja—of Kheṭa, Grāma, Pura, Palace, citadel, roads, highways, boundaries, public halls, forests, gardens and other things. Even mountaneous altitudes, watery depths,[187] valleys, ravines and dales[188]

प्राशयेन प्रमातव्याः खातक्रकचराशयः ।
तलोच्छ्रयान् मूलपादान् जलोद्देशानधः क्षितेः ॥
तथा दोलाम्बुशस्त्रादि पातमानविनिर्णयम् ।
शैलखातनिकेतानि सुरुङ्गामानमान्तरम् ॥

Aparājitapṛcchā (1200 A. D.) speaks eloquently of survey and cartography in the following lines[189]—

हस्तलाघवसम्पन्नो घाटचित्रादिकौशलः ।
चक्षुः प्रत्यक्षकृच्चैव हृद्दृष्टं ज्योतिषो यथा ॥
सूत्रधारोपचारोऽर्थ वास्तुशास्त्रनिबोधनम् ।
भुवनकोशविज्ञानं प्रमाणं सूत्रकर्मणि ॥
समुद्रोपकण्ठदेशमहाशैलाश्रमादिकम् ।
भूमिभागैरनेकैश्च परीक्षा सूत्रकर्मणाम् ॥

Here the line "भुवनकोशविज्ञानं" (science of Geography) प्रमाणं सूत्रकर्मणि clearly indicates that surveying was treated as a particular branch of or included in the science of Geography, as it is done in modern times. Secondly the last two lines point that ocean coasts, mountains flanking them and all adjoining varigated areas were carefully surveyed. It is a further evidence that the Indians were the first originator of geodetic survey which Kālidāsa has referred to so

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187. We find definite mention of oceanic bathymetric survey in the earliest Buddhist literature, which would be discussed subsequently. No, wonder, therefore, that by the time of Bhoja this science might have developed considerably.

188. The Samarāṅgaṇa. IX. 33 to 35.

189. Sūtra 50, verses 4, 6, 7.

early and which has already been discussed in the anterior pages.[190]

The same source refers to the maps and plans in the clearest terms[191]--चित्रपट्टप्रभेदाश्च रेखाचित्रसमुद्भवाः ।

The Mānasāra describes in detail the manufacturing of surveying instruments, which deserve our notice. It has—[192]

"Śami (Acacia suma), Śāka (ocinum sanctum), Chāpa (bowtree), Khadir (Acacia catechu), Tamālaka (Xanthochymus pictorius), Kṣiriṇī (milk tree) and tindinī (tamarind tree) are known as the kinds of woods for yard stick (हस्तदारु).

"After selecting the wood (for yard stick) it should be dipped into water for three months. After having been washed it should be taken out (of water) and be split by the carpenter. The snapped part of that hewn timber should be shaped into a solid four sided (piece)."

"It should be one cubit long, one Aṇgula ($\frac{3}{4}$") broad, its thickness is stated to be a half aṇgula. The yard stick (literally cubit measure हस्त) should be accurately marked."

"Either Kramuka (bettle nut tree) or Veṇu (bamboo) is stated to be (fit as) the timber for the (measuring) rod (which should be) neither bent, nor broken nor porous, but smooth."

"Viṣṇu is stated to be tutilary god of (the wood for) both the yard-stick and the measuring rod (दण्डदारु)."[193]

"The rope-maker should make the rope (रज्जु—a measure) with the spilit husk of coconut with the Kuśa grass (poa cynosuroides), the bark of the "banyan tree, silk cotton and

190. Cf. anterior pages of this chapter on Geodetic Survey.
191. Aprājitapṛcchā, Sūtra 2, verse 27.
192. II. 59-74. (Lines) - P. K. Acharya.
193. Measuring rod (दण्डदारु) = 4 cubits = 6 ft. approximately, and Rajju—56— 60 ft. nearly ; compare it with Gunter chain of the present day.

kinśuka (butea frondosa) thread, bark of the palm tree, and ketaka (pandanus odoratiosimus) or with any other suitable bark,"

"Measuring side wise, the width of the measuring rope should be one aṅgula."

"The rope should be made free from knots and three fold for (measuring the architectural objects of) the gods, Brāhmaṇas (earthly gods) and kings (Kṣatriyas), two fold (for those of) Vaiśyas. and of single for those of the Śūdras."

Similar information is furnished by the Mayamatam[194] also but its description is sketchy ; the comparable lines are—

अष्टयष्टचायत्तारज्जुस्तालकेतकवल्कलैः ।
कार्पास-पट्टसूत्रैश्च दर्भैन्यग्रोधवल्कलैः ॥
अङ्गुलाग्रसमस्थूला त्रिवर्तिग्रन्थिवर्जिता ।
देवद्विजमहीपानां शेषयोश्च द्विवर्तिका ॥

Jain Contribution :—

From a close study of the scientific and non-scientific literature of the Jainas and other sources of antiquity and archaeology, it appears that the Jainas made little original and independent contribution to the art and science of survey and cartography in India. They borrowed not only spirit and inspiration of the Vedic or Brahmanic system, but almost everything of the latter. Still it is worthwhile to examine their knowledge on the topic of survey and cartography as revealed by their scriptures.

Perhaps the first mention of survey in the Jain literature is found in the Tattvārthādhigamasūtra.[195] Commenting on the particular aphorism of the text bearing on this branch of knowledge, Akalaṅkadeva says, ".....Eight madhyās equal one utsedhāṅgula. These are used to measure images of natural shrines of.....Then 500 utsedhāṅgulas equal one

194. VI. 14-15.
195. III. 38.

Pramānāṅgula. This is the Ātmāṅgula of the first Cakravarti monarch of the Avasarpiṇī. At that time villages, towns and the like are suryeyed and measured by this measure. In other ages different Ātmāṅgulas are used for the purpose. Pramāṇāṅgula is used to measure the dimensions of continents or islands, oceans, vedikas, mountains, vimānas (space regions), infernal regions....." Thus it can be seen that the Jainas were acquainted with the elaborate survey of every kind of Geographic feature. There is mentioned another very conspicuous fact here that "oceans" were also surveyed or measured. This might have positively included survey of coastal regions and watery stretches ; but can it contain any reference to geodetic and bathymetric survey also ? Chronological sequence and view of the Buddhist sources, Kālidāsa and Samarāṅgaṇasūtradhāra discussed just above point that the answer to the foregoing question is in affirmative, specially when we remember that the date of the commentary is near about 800 A. D,

The Tiloyapaṇṇattī[196] (C, 500 A. D.) testifies to the same developed stage of survey (geodetic and bathymetric inclusive), which we have come across in the Tattvārthādhigamasūtra. It remarks, "continents, oceans, Vedī, rivers, lakes, tanks, world and Bhārat country are surveyed with the measure of Pramāṇāṅgula". This sentence further points to another notable fact that by 500 A. D., the date of the composition of the Tiloyapaṇṇattī, survey of whole of India must have been performed with considerable accuracy.

With the concurrent evidences of Brāhmaṇic, Jaina and Buddhist sources the present author has established beyond the least doubt that world maps were drawn by the ancient Indians, at least 500 years before Christ. The Brāhmaṇic sources have already been surveyed in the anterior pages. The Buddhist lore would be examined in the sequel. For the present, in the logical sequence, we take up Jain tracts.

196. I. III.

The most unmistakable evidence of cartography of maps of world or India in Jain literature is supplied by the Vṛhatkalpasūtra of Bhadrabāhu, who is known to have flourished round about 400 B. C. The commentary[197] in the particular verse, which also dates back to a period near about the Christian era fortifies the same thing.

The text of the Vṛhatkalpasūtra reads[198]—

तरुगिरिनदीसमुद्दो भवणावल्लीलयावियाणाय ।
निद्दीसचित्तकम्मं, पुन्नकलस-सोत्थि याई य ॥ २४२६ ॥

The commentary on it runs, "That painting should be recognised as sanctimonious where maps and pictures of trees like mango; of mountains like the Himālayas, of rivers like the Gaṅga and Sindhu; of oceans like Lavaṇodadhi (one of traditional oceans); of buildings like Catuḥśālā; of flora like Nāgavallī; of creepers like Mādhavī and Caṁpaka, and their arbours; of filled pitcher (Kalaśa), Swastika and other auspicious objects are drawn." Cf. Fig 28. Here representation of the Himālaya and other mountains, of Gaṅgā and Sindhu together with various other rivers and Lavaṇodadhi and different oceans explicitly evinces that entire earth might have been shown in the form of a map. Reference to various mountains and rivers unequivocally evidences that continents were also drawn. It is immaterial that in all probability it would have depicted the world, oceans, and other features according to the conventional mythological geography.

Mapping of Jambūdvīpa was known to the Tattavārthādhigamasūtra.[199] The Commentary on the sūtra shows that those people were acquainted with the concept of scale also

197. Cf. निर्युक्तिकार भद्रबाहु in Winternitz, Vol. II. p. 476. Saṅgha Dāsa Gaṇin might have flourished near about 3rd or 4th century A. D.
198. Part III.
199. III. 38.

Fig. 29

A sort of Blockdiagrams (Jaina). After Laghukṣetrasamāsa in Vārāṇaseya Sanskṛta Viśvavidyālaya, Varanasi.

It is an attempt to present a profile of the topography consisting of mountains, lakes and rivers. It is oriented to the North. It can easily be designated as the crude block diagrams.

There are positive evidences to show that the Laghukṣetrasamāsa is based on the Vṛhatkṣetrasamāsa, hence this diagram must trace its origin from the latter work and thus its inception may belong to 700 A. D. (the date of the latter treatise) or even to an earlier era.

and could reduce large-sized object on a small scale. It runs as follows:—

"संख्येयप्रमाणावगमार्थं जम्बूद्वीपतुल्यायामविष्कम्भा योजनसहस्रावगाहः वृद्ध्या कुशूलाश्चत्वारः कर्तव्याः—शलाका प्रतिशलाका महाशलाकाख्यास्त्रयो व्यवस्थिताः चतुर्थोऽनवस्थितः।"

"for knowing the dimension to be computed, four pits measuring one lakh yojanas equal to the dimension of Jambūdvīpa and one thousand Yojanas in depth and bearing the appellation Śalākā; Pratiśalākā, and Mahāśalākā should be constructed".

From the narrative of the Vṛhatkṣetrasamāsa it appears that the text would have been acquainted with various types of delineation or mapping of the world. We have got actually maps of later date drawn wholly based on the geographic information furnished by this work.

There is another Jain work Kṣetrasamāsa or Laghu-Kṣetrasamāsa which seems to have been written on the basis of the above mentioned older work. The present researcher has examined a MS. of the Kṣetrasamāsa which was copied more than a hundred years ago. It contains a large number of coloured geographic maps including world maps and such geomorphological representations which may be called crude—*block diagrams of modern times.*" Cf. Fig 29. The study of these maps points to a very long existing tradition of Jain cartography which might have germinated several countries before 1200 A. D. (A few maps of this text are reproduced here to give an insight in the long vista).

Colonel Wilford[200] (in the 18th century) also possessed a copy of Jain Kṣetrasamāsa, which contained several world maps and other specimens of Indian cartography. He has designated the former as,—fanciful delineation of the world and of Mount Meru".

The present researcher has come across a MS. of the Saṅgrahaṇī or Saṅghayaṇī,[201] which contains rough maps

200. Asiatic Researches. vol. VIII, p. 269.

201. Kept in Saraswatī Bhavana. Varanasi.

of the world and the like. The MS. appears to be 200 or 300 years old.

All this shows that Jain Geographic treatises would have been illustrated with various types of maps and diagrams from very great antiquity, definitely much earlier than 1200 A. D.

The Tiloyapaṇṇattī[202] gives a diagramatic representation or map of the sky, which it calls तस्स ठवणा (तस्य स्थापना) and which is reproduced below :—

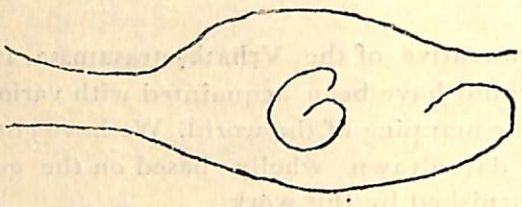

Fig. 30

Madhava Candra Traividhya[203] (1025 A. D.) has used a term "संदृष्टि", which perhaps had a meaning "geographic diagrams or illustrations" also.

The Jambūdvīpaprajñapti[204] has referred to the same type of architectural plans or maps, as are found in Brāhmaṇic treatises, namely, Nandyāvarta, Vardhamāna, Swastika Sarvatobhadra and the like.

Buddhist Perspective :

On the testimony of Buddhist scriptures and antiquarian sources, it can be unreservedly remarked that the Buddhist period of Indian history has made most notable and outstanding contribution to the cause of survey and cartography in India. We hear for the first time in Buddhist records about some sort of oceanic Bathymetric survey.

202. I. 283.
203. Trilokasāra commented by him.
204. Vakṣaskara III. leaf 199-200.

In the Dīghanikāya, nearly 500 or 600 B. C., we find mention of a separate science designated as "खेतविज्जा" meaning "land surveying and mensuration"[205]. In the Udāna there is a reference to the same.[206]

The Kurudhamma Jātaka[207] has got an extremely interesting anecdote illustrating the punctiliousness and accuracy with which survey was performed. In it king's representative or official and the owner of the land participated on equal footing so that the latter might not have any grudge. The king's survey official was called—"Rajjugrahakamacco" (रज्जुग्राहकमच्चो) one who held the रज्जु or measuring string or tape. A part from the Rajju, stick were also used in this surveying. In another Jātaka[208] the king's officer for performing survey of the fields has been designated as—'राजकम्मिकखेत्तप्रमाणगहणत्थाय।" Survey of entire Jambūdvīpa is spoken of thus in the Divyāvadāna[209] सर्वजम्बूद्वीपान्-मापयेयम् मापयित्वा....."

The following lines of the Vinaya Piṭaka (C. 400 B. C.) give a considerably detailed account of large scale surveying of various geographic features and delimitation of boundary—

"I prescribe, O Bhikkhus, that you determine a boundary. And it thought to be determined, O Bhikkhus, in this way. First the landmarks are to be proclaimed; a land-mark consisting in a mountain, in a rock, in a wood, in a tree, in a path, in an anthill, in a river, in a piece of water. Three land-marks, having been proclaimed, let a learned, competent Bhikkhu proclaim the following Natti before the Saṅgha—"Let the Saṅgha, revered sirs, hear me. If the Saṅgha is ready, let the Saṅgha as the land marks have been

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205. Eng. Trans. "Dialogues of the Buddhist". J. W. R. Davids Part I, p. 18, notes, 3.
206. "खेतविज्जा" III. 9.
207. Fauseboll no. 276.
208. Ibid. no 467.
209. Avadāna XX. p. 292.

proclaimed all round, by these land marks determine the boundary of common residence and communion of Uposatha. This is the Natti. Let the Saṅgha, revered sirs, hear me. The Saṅgha determines the boundary."[210]

"At that time the chabbaggiya Bhikkhus, considering that fixing of boundaries had been prescribed by the blessed one, fixed boundaries of excessive extension, of four Yojanas, five Yojanas, six Yojanas....."

"Let on one, O Bhikkhus, determine a boundary of excessive extension, of four, five or six yojanas..... I prescribe, O Bhikkhus, that you determine boundary of three yojanas extent at most."[211]

The Dīpavaṃśa a text of 4th century A. D. alludes to surveying and fixing of boundary thus, "..... he fixed the boundaries of the villages."[212]

In the Mahāvastu, people professing a particular avocation are specifically named as "स्थपतिसूत्रधारका," it points that the work must have been acquainted with survey and cartography both according to the meaning of the two technical terms expressed in the compound.

The Buddhists must have been drawing and using the world map at least 500 or 600 years before Christ, is evidenced by the Mahāummagga Jātaka. Its following lines are noteworthy in this connection—

".....अपि च उम्मग्गस्य गब्भे द्विसु पास्सेसु कुसला चित्रकारा नानाप्पकारचित्रकम्मं करिंसु: सक्क-विलास-सिनेरु-परिमण्ड-सागर-महासागर-चतुमहाद्वीपाहिमवन्तानोतत्तमनोसिलातल....."[213]

"Moreover in the tunnel on either side, clever painters made all manners of paintings: the splendour of the Śakka

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210. Eng. Trans. J. W. R. Davids and Oldenberg. Part I, II. 6. p. 249.
211. Ibid. II. 7. 1. p. 250.
212. Edition and Trans. by H. Oldenberg, XI. 3. p. 164.
213. Jātaka no 546, Fauseboll, p. 432.

(शक्र), the zones of mountain sineru (मेरु), and the sea and the ocean, the four continents, Himavant, lake Anotatta the Vermillion mountain....."[213a]

Thus it is clear that on world map drawn by the Buddhists continents, oceans, mountains, lakes and most probably other geographic features were also shown, and this work was carried on by expert cartographers. Colours were also used as is done in modern map and Atlases.

From the Ādikarmapradīpa we gather that in a particular ritual, world maps were prepared and continents were coloured with different hues. About these maps Poussin observes, "In the diagrams which the Buddhist cult (great vehicle and Tāntrism) uses for the "offering of the Universe", the continents are represented: (1) half moon (अर्धचन्द्र) and white, (2) triangular (त्र्यस्र) and golden; (3) circular and red, and (4) Square and dark blue."[214]

Map-making and diagram-drawing or a particular type of cartography were practised in their own fashion in or before the times of Divyāvadāna. These maps and the like were mixed together and represented not only geographic details (continents and other things) but also subjective things and ideas. Lettering and legend writing were also done. This sort of maps was prominently displayed on public buildings or other edifices. These cartographic specimens bore a special name "पञ्चगण्डकचक्र" or "पञ्चगण्डकसंसारचक्र".

213a Ibid Cowel, p. 223.

214. Encyclopaedia of Religion and Ethics "Cosmogony and Cosmology" (Buddhist), Vol. IV, p. 133. According to Poussin the work belongs to late centuries of Christ, when Tāntrism had developed much. This Buddhist ritual can be compared with the Brāhmaṇic sacerdotal practice of Brahmāṇḍadāna and Dharādāna. Perhaps the former might have borrowed it from the latter. But the former drew the details from their own mythological or semi-mythological geography.

Sahasodgataprakaraṇāvadāna[215] describe it as follow:

"न सर्वत्रानन्द मौद्गलायनो भिक्षुर्भविष्यति, मौद्गलायनसदृशो वा तस्माद् द्वारकोष्टके पञ्चगण्डकं चक्रं कारयितव्यम् । उक्तं भगवता द्वारकोष्टके पञ्चगण्डकं चक्रं कारयितव्यमिति । भिक्षवो न जानते कीदृशं कारयितव्यमिति। भगवान आह—पञ्चगतयः कर्तव्या नरकास्तिरयञ्चः प्रेता देवा मनुष्याश्च । तत्राधस्तान्नरकाः कर्तव्यास्तिरयञ्चः प्रेताश्चोपरिष्टाद्देवा मनुष्याश्च चत्वारो द्वीपा कर्तव्याः पूर्वविदेहोऽपरगोदानीय उत्तरकुरुजम्बूद्वीपश्च । मध्ये रागद्वेषमोहाः कर्तव्या, रागः पारावताकारेण, द्वेषो-भुजङ्गाकारेण (बुद्धप्रतिमाश्चैतन्निर्वाणमडलं उपदर्शयन्ति) कर्तव्याः । औपपादुका सत्वा घटीयन्त्रप्रयोगेण च्यवमाना उपपद्य मानाश्चकर्तव्याः । सामन्तकेन द्वादशाङ्गः प्रतीत्य समुत्पादोऽनुलोम प्रतिलोमः कर्तव्याः । सर्वमनित्यतया ग्रस्तं कर्तव्यं गाथा द्वयं च लेखयितव्यम् .....आरब्धं.....करिष्यति ।"

In another Buddhist text Āryamañjuśrīmūkakalpa (2d century A. D.) we read about the preparation or cartography of the map of Jambūdvīpa and the entire world thus—

जम्बूद्वीपमिमं कृत्स्नं स्तूपालङ्कृतभूषणम् ।
कारयन्तु भवन्तो वै धातुगर्भा वसुन्धराम् ॥[216]

"Let the whole Jambūdvīpa decorated with topes and the earth with minerals be drawn."

On the authority of Dīpavansa it can be asserted that the Buddhists prepared maps, plans and charts in connection with building towns.[217] Mahāvanśa furnishes the same information saying, "तदालेखं लेखयित्वा"—having drawn a plan of it."[218]

Near about the half millenium B. C. military maps and war-plans were quite common in connection with military

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215. Divyāvadāna, Avadāna, no. XXI, p. 300. Also cf. Avadāna no. XIII, p. 180 and Avadāna no. XXXVII, p. 551.
216. Paṭalavisara. 53, p. 607.
217. Chapter XIX.
218. Mahāvasśa, edited by Turner, p. 162.

campaigns and engagements. The Tacca-Sūkara-Jātaka[219] refers to types of battle-arrays-शकटव्यूह (cart array) and पद्मव्यूह (lotus array).

Use of Conventional Signs :—

From the above discussion it is clearly established that ancient Brāhmaṇic people, Jainas and Buddhists all prepared maps of world, India, other regions and sea charts and showed on them oceans, mountains, rivers, lakes, towns, and other necessary geographic features. For all this they must have used conventional signs. Very old maps are non-existant and descriptions of maps furnished by various branches of literature are either insufficient or quite meagre, so much detail cannot be provided regarding these conventional signs. However, from the extant and available maps (which are a few centuries—utmost four or five hundred years old and which have been examined by the present researcher so far) it appears that oceans were shown by circular rings coloured blue, similarly the rivers were represented by crude curved double lines coloured blue in the middle. Generally lakes and all other water-bodies were coloured blue. Mountains were shown by flatenned circles (⬭) or regular or crude rectangles (▭) or irregular figures bounded by lines. For showing towns and cities rectangles were used, which were generally bereft of any idea of proportion. The Brāhmaṇic people, Jainas, and the Buddhists all the three sects frequently used various colours in their cartography, which bore some affinity to and must have derived considerable inspiration from their paintings. This statement is well-founded on the survey of the preceding pages of this chapter. Some plates of old maps have already been given, they are helpful to an extent to illustrate and testify the point.

Voyages of the twin sciences

Any account of Indian survey and cartography would be deemed incomplete, unless it embodies at least a skipping reference to the brilliant achievement of Cola monarchs in this field.

219. Fauseboll Jātaka no. 492.

Rājarāja, one of the ablest and most magnificent sovereigns of not only of Cola dynasty but also of whole southern India, took great initiative in performing the elaborate land survey of his territory in 1,000 A. D. During the reign of one of his very capable successors Kulottuṅga (1070-1120) tht work of survey started by Rājarāja, reached its pinnacle. Kulottuṅga ordered another land-survey in 1086. By a strange coincidence this is the date when Domesday survey was performed in England during the reign of William the conqueror. Under the latter Cola monarch third gigantic survey was made in 1110 A. D.[220]

The Colas had reduced the whole of the Bay of Bangal to a lake and they dominated in the Indian oceans in the east and west both and they had undertaken successful military compaigns and naval engagements against Śailendra Empire in the Bay of Bangal and eastern Indian ocean. This could never have been possible unless they must have had elaborate and good sea charts and maps. From this it is certain that they possessed quite accurate account of reconnoitering of the seas and adjoining coasts and lands.

With the expansion of Indian culture and art and sciences in the distant colonies, the art of Indian survey and cartography travelled beyond the oceanic stretches.

Delimitation of boundary by natural objects on some topographic features pointing towards large territorial survey and some sort of mapping are thus spoken of in the following lines of a rock inscription of king Bhadravarmā of Campā who ruled in the 4th century A.D.—

".....भद्रवर्मणा मानुष्यमध्वानं ज्ञा (त्वा) भद्रेश्वराय अक्षयी नीवी दत्ता यथा (पूर्वेण) सुलह-पर्वतो, दक्षिणेन महापर्वतः, पश्चिमेन कुचक पर्वतः उत्तरेण म(हा नदी) परिमाणाभ्यन्तरा सकुटुम्बजना भूमिर्दत्ता जनपद-मर्यादा षड्भागेऽपि..... स्वामिना दशभागेनानुगृहिता देवस्य देयेति ।"[221]

Cf. Fig. 31.

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220. The Struggle of Empire— R. C. Majumdar (editd). pp. 235,244.

221. Myson Stelac Inscription, no. 4.

To face P. 316

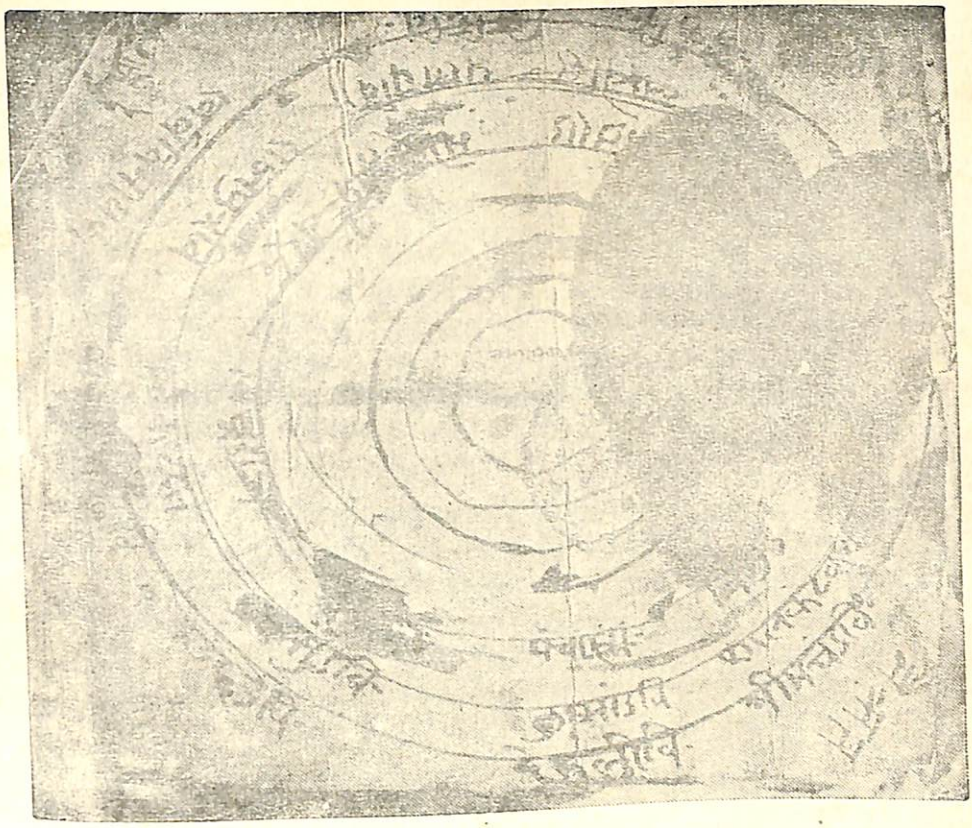

Fig. 31.

The map (drawn in some pristine sacerdotal cartographical-style by the great grandfather of Shri Maya Prasad Tripathi, some 200 years ago) shows Varanasi City in terms of the venues of the sacerdotal shrines of Lord Vināyaka (Gaṇeśa) with various appellations. It resembles the style of the Pauraṇic world map with circular rings of oceans and continents. It is conspicuous by an improvement on the old Pauraṇic style. It has clearcut orientation and mention of the compass directions.

The map may be viewed as religio-cartographical portryal of Kāśi in terms of the venues (bench—mark—like points) of 56 Vināyakas. Seven concentric circles like the representation of the seven continents (the earth) may be interpreted to serve as a sort of projection for showing geographic areas. The traditional description of the map is found in various Puraṇas from the beginning of the Christian era. (The above map was a little spoiled by water and oil).

Development of Geographic Knowledge In Ancient India

ENVOI

Was Geography A Separate And Systematic Science In Ancient India ?

Geography—a separate and systematic Science
Physiognomy
Status of Geography
Separate entity and Identity of Geography
Monographs—Dissertations
Art of Geographic Treatise writing

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ENVOI

WAS GEOGRAPHY A SEPARATE AND SYSTEMATIC SCIENCE IN ANCIENT INDIA ?

Still there is a class of people which is gravely sceptic about the fact whether Geography was a separate and systematic science in ancient India. But this predisposition and presentiment is only due to ignorance and no other reason.

It is but a truism to remark that Indians from the hoariest past had come to have a concept of Geography and had realised the importance of Geographic knowledge and actually endeavoured to put it on record, of course, in their own primal fashion, creating a separate section, which is found in their extant tomes or written documents of literature, culture and civilisation. Even the most ultra-modern and fastidious critic who has got the least logical and scientific sensibility of historical evolutions and perspectives would little hesitate to characterise them a piece of geographical composition, however puisne and crude it may be.

One of the most conspicuous composition of this type belonging to the first known germinating period is the celebrated River Hymns of the Ṛgveda.[1] Its descriptions are sufficient to testify to a geographic epistemological sensibility of the earliest Indians.

The Atharvaveda marks out the most splendid milestone on this path of progress. In this connection we can scarcely afford to skip over its XIX. 17. 1-9, but it is its Pṛthivī-Sūkta[2] which brings laurels to India in her being first to recognise and chisel out the physiognomy of geography as a separate, distinct and systematic branch of enquiry. It is a

1. X. 75.
2. Kāṇda XII.

brilliant specimen of a quite methodical geographic narrative accompanied with almost all its paraphernalia couched in charming poetic language and scintillating throughout with the true conception of the science. It provides a succinct account of topography, physiography, flora, fauna, agricultural activities, inhabitants, their manners and customs, mineral wealth and its exploitation, languages and races of the earth. This Pṛthivīsūkta can be easily styled the progenator of the idea and concrete corpus of the posterior Bhuvanakośa, Bhūgola varṇanam or Bhūgolādhyāya. It precedes or heralds such compositions of all nations in promulgating the elements, principles, raison d'être and methodology of geography which are vouchesafed by the modernity. Or in other words, it may be concisely designated as the first vivacious germ of all geographic disquisitions or tomes of the whole world.

The section VIII. 14 of the Aitereya Brāhmaṇa[3] attempting to present the regional geography of India is another specimen of such writing belonging to the Vedic age.

Hereafter the personality of the science of Geography improves from age to age and it becomes gradually more and more distinct.

The Rāmāyaṇa devotes four chapters[4] to this equiry and pursuit. The circumference of interest widens by leaps and bounds and subtle details arrest our special attention and an atmosphere of profundity of knowledge of geography—of land, people and ancilliary panorama is is created, the aroma of which can be sensed at once at the first perusal.

The Mahābhārata[5] proceeds a step further and in its encyclopaedic realm erects two separate and specific edifices

3. The Chāndogya Upaniṣad has recognised a special science "of the heaven and earth," this must have been Geography. (VII. 2.1, p. 470). In the evolutionary vista of the Atharvaveda and Aiterya Brāhmaṇa this inference fits very well.
4. IV. 40-41-42-43.
5. VI. 11 and 12 and others.

for geography or Bhuvanakośa, christening them as Bhūmī-parva. In another chapter it treats of climatology and meteorology in detail.[6]

In the ramification of this process geography comes to be treated in three forms—(i) In the encyclopaedia of the Purāṇas and Tantras, (ii) becoming an indispensable organ of astronomy ; and (iii) in exclusive treatises on geography proper (Bauddh, Jain and Brāhmaṇic).

The Purāṇas coined a technical term "Bhuvanakośa" which is fully identical in connotation and denotation with the modern term "Geography". Generally every Purāṇa, except one or two, has devoted ten to thirteen or sometimes fifteen chapters or even more than that to the treatment of Geography. Usually these chapters are arranged in a logical and systematic continuation and read as a compact whole.

The Purāṇas have dwelt on not only regional or general geography, but also on cosmogony, cosmology and astronomical geography and earth and its planetary relations at length. Some of the Purāṇas, for example, the Brahmāṇda,[7] Vāyu,[8] Matsya,[9] contain a full-fledged separate chapter on climatology, meteorology and the allied phenomena. These and several others embody good scientific account of various facts of oceanography.

In the Taṇtras also Geography came to occupy a separate and significant position. The Tantrāloka of Abhinavagupta marks out a chapter Deśāddhwaprakāśana[10] for the discussion of Geography. In the Tārātantra and Gālava Tantra both, there is a portion concentrating exclusively on geography. Thus even the most fantastic, crude and peculiar branch of Indian literature had recognised the importance

6. XII. 329. 36-51.
7. Chap. 22.
8. Chap. 51.
9. Chap. 125.
10. Vol. V, chap. 8.

of geography and devoted peremptorily considerable space to its treatment. The climatological treatise Meghamālā appears to be another remarkable achievement of the Tāntric geographic talent.

In India for a pretty long time geography formed an essential branch of astronomy or Jyotiṣa or sometimes it was totally identified with the latter ; occasionally the two Sanskrit terms for astronomy and geography are found interchangeable. In the Purāṇas the Bhuvanakośa includes plenty of astronomical subject matter, and in the age of Siddhāntas the term Jyotiṣa invariably incorporated all that was deemed geography.

Be that as it may, in every astronomical work we have got a separate chapter on geography. In the Āryabhatīya this science is succinctly discussed in the Golapāda, in the Sūryasiddhānta it is designated as Bhūgolavarṇanam and Bhāskarācārya has named that chapter as Bhuvanakośa in imitation of the Purāṇas. In a manuscript of Vaśiṣṭhasiddhānta (Kept in the Deccan College Museum, Poona) written earlier than 1200 A. D. there are two long chapters on geography under the caption Bhūgolāddhyāya.

So far as the nature and scope of the Bhūgolavarṇanam of the Siddhāntas are concerned, one of the earliest Siddhānta, namely, the Sūryasiddhānta provides remarkably logical information on the relevant topics. It evinces extremely refined and high standard of geographic enquiry. The enquirer puts the following questions.[11]

11. XII. 2 to 8.

Compare this with the geographic inquisitiveness of the Buddhists contained in the following words of the Laṅkāvatārasūtra (c. 343 A. D.), chap. II—

".....Whence are the earth, stars, constellation, the moon and the sun. Whence are the clouds in the sky ?

"Why are the lands shaped like the moon, the sun, the Sumeru, the lotus, the Śrīvatsa and the lion ?

".....What is the size and shape of the earth ? What is its support ? What are its divisions or regions ? What is the arrangement of the nether worlds or strata ? How are day and night caused through the agency of the sun ? What is the nature of its motion, illumination of the world or insolation ? What is the nature of relationship of earth, planets and other heavenly bodies ? What is the dimension of the universe ? What is solar and siderial time or year ? Why is the sun hot in the summer and not so in the winter ? How do you further explain insolation and albedo and their varying quantities ?"

In the modern Indian languages of the Sanskritic origin, the term Bhūgola is used for the science of geography. It is an extremely old term, the meaning of which has remained unchanged through the ages and still continues to be so. So far as astronomical treatises are concerned, it was used for the first time in the oldest tract—Sūryasiddhānta.[12] Its use in the Vaśiṣṭhasiddhānta has already been referred to.

But it appears that this term had gained currency several centuries before Christ, as is evidenced by the following

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"Wherefore are the lands shaped like a capsized and upturned net of India which is composed of all sorts of Jewels..... ?

"Wherefore are (the lands) shaped in the form of a lute or drum ? Like various flowers and fruits ?

"And also what are measurements of mountains, Sumeru and the earth ? What is the measurement of the ocean, moon and sun ?

"Whence is the arising of the clouds ? And whence do the seasons do ?"—*34*.38-83. In this continuation questions regarding measures of time and space are also posed. Here we see that the above querries embrace almost all the modern branches of geography.

12. Chapter XII and at other places.

line[13] of the Padmapurāṇa which is said to be one of the oldest ones—

भूगोलः खगोलश्च ज्योतिश्चक्रविनिणयः ।

The strongest evidence of the fact that geography existed as a separate and distinct science occupying a full-fledged status comes forth from the extant treatises exclusively on geography proper. It is noteworthy that we have got very old specimens of such works [14] which were composed by all the three important sects of India, that is, the Buddhists, Jainas and Brāhmaṇic people.

Perhaps the Buddhists were pioneer in this field. But it is strange that they merely ushered in the dawn and then disappeared from the stage for good. Their only extant voluminous treatise of this class is Lokaprajñapti,[15] which was composed about 6th century B. C. From this it is clear that geography has come to exist in its full stature in India prior to all nations, of course, the particular science would have been in the "Ape-stage" in the Darwinian terminology of evolution. From very ancient days the Buddhists had special nomenclature for those well-versed in geography and oceanography. The former discipline was designated as Lokākhyāyikā,[16] and the latter as samudrākhāyikā.[17]

In this field the Jainas have done extremely valuable and substantial work which can be characterised simply unrivalled as neither the Brāhmaṇic writers nor the Buddhists can compare with it either in bulk or subject matter and variety of topics. Archæological discoveries and historical researches made so far have brought to light nearly

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13. Pātāla Khaṇḍa I. 4.
14. For an exhaustive list, cf. the section A of the Bibliography at the end.
15. For detailed discussion cf. the anterior pages of chapter 7 of the present work.
16-17. Mahāniddeśa (2nd or 3rd century B. C.), vol II, p. 368.

twenty-five [18] such works on geography proper. The Jainas also had ushered in the composition of this class of treatises at least 4th century before Christ. The Sūryaprajñapti is one of the earliest works belonging to this category which was written in the fourth century B. C. Of still older antiquity and greater importance from the real geographic point of view is Dīvasāgara-paṇṇattī, which must have been composed prior to 400 B. C. Though it is non-existent, it has been several times referred to in the posterior standard monographs on geography.

It cannot be said with certainty as to when in the Brāhmaṇic tradition the writing of real geographic tracts began. If we think in the vista of evolutional chronology commencing from the Vedic dawn and passing through the Paurāṇic age and Siddhānta period, a hypothesis overtakes the mind that some disquisitions of the foregoing category ought to have existed at least contemporaneous with the earliest initiation of the Buddhists and Jainas. But unfortunately we have got no such extant sample of the period, and our whole edifice of the hypothesis collapses. Total darkness would ever prevail in this domain, unless some startling discovery unravels further the hoary past shrouded in mystery, but there does not appear much hope for this.

There are, however, evidences to testify that from the fifth century onwards, the Brāhmaṇic people also undertook the composition of exclusively geographic books. The first of this kind is the Vikramapratideśavyavasthā composed in the 5th century A. D. It has already been surveyed in some detail in the seventh chapter of the present disquisition. In this connection we may repeat the names of Muñjapratideśavyavasthā, Bhojapratideśavyavasthā, and Bhuvanakośa of Rājaśekhara which appear in quick succession or synchroniously on the indigenous stage of science of geography.

18. They were all written before 1200 A. D. A few works were composed after this period also. Their complete repertory would be furnished in a separate dissertation as envisaged by the present author.

The aforesaid tradition continues uninterrptedly, but it generally presents a dismal and monotonous picture which lacks originality, independent initiative and spirit of improvement and is chequered with long subsisting conventional ignorance and erroneous views. Among later treatises, the enumeration of Bhūgolapurāṇam, Bhūgolavarṇanam, Bhūgolotpatti-varṇanam and Lokamanorama is sufficient to justify this remark.

The subsequent period appears to have produced scholars who knew the real geography and its genuine concepts with considerable accuracy and resembled the modernity to a good extent, but it remains unaccountable and totally inconsistent why standard and authentic books were not composed on geography proper, specially when there existed the old tradition. Parmeśvara (1365-1460), the author of the Goladīpikā and the celebrated commentator of the Sūryasiddhānta hailing from Keral is the signally outshining name among the aforesaid class of scholars. Cf. Figs. 32, 33.

The entire foregoing circumspection and its critical and categorical epitome are further supported by the following appendix of the selected ancient technical terms given on the posterior pages.

To face P. 326

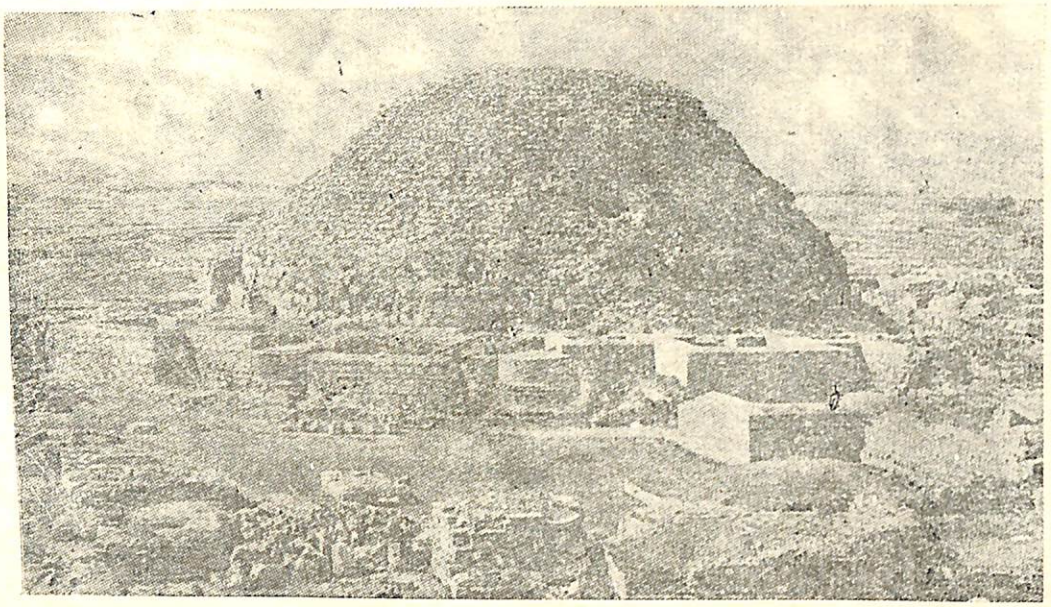

Fig. 32
Greatest Centres (I) of Geographical teaching and Research in Ancient India—Takṣilā University.

क

करक, करका = Hail or hailstorm.

करकासार = Shower of hail.

काट = Inaccessible forest (Taittirīya Sanhitā IV. 5. 9. 1).

कालिकावात = A kind of furious storm (Divyāvadāna, p. 41).

किंशिल = Pebbly ground (Vājasaneyi-Sanhitā, XVI. 37-45).

कुटिलबाल = Curely hair (Vṛhatsanhitā, chap. 67).

कुमध्यरेखा = O° longitude Śīṣyadhīvṛddhida, Praśna, 16).

कूल = River bank.

कोशकृमि = Silk worm (Mahābhārata, XII. 330. 29).

क्षयण = Habitable place (Taittirīya Sanhitā IV. 5. 9. 1).

ख

खस्वस्तिक = Zenith.

ग

गह्वर = Mountain hollows (Vājasaneyi-Sanhitā XVI. 37 to 45); an abyss (Taittirīya Sanhitā, IV. 5. 9. 1).

गिरि-गह्वर = A gorge (Kalhaṇa VIII. 255).

गिरि-द्रोणी = Mountain valley (Kalhaṇa VIII. 2763).

गिरिद्वार = A pass.

गोलक = Globe.

च

चण्डानिल = Typhoon or a violent gale (Jātakamālā, Speyer, p. 12).

छ

छेद्यक = a special illustrative cartography but can logically be taken to denote Map-projection (Sūryasiddhānta and other Siddhāntas).

ज

जनपद = A small geographic or political division, resembling a district or a region.

त

तीर्थ = a ford.

त्रिफलक = Plane table (Siddhānta Śekhara, IV. 122).

द

दकार्गल, दगार्गल = Science of sub-terranean water (Vṛhatsanhitā chap. 53).

दीप = A muddy river (Rāmāyaṇa III. 30. 5).

ध

धन्व = A desert (Ṛgveda ; Pāṇini IV. 2. 121).

न

निरक्षदेश = Equator (Siddhāntaśiromaṇi).

निर्झर = A water-fall.

निर्दर = Caves or cracked stones with joints (Rāmāyaṇa II. 92. 10).

नियमिक ज्येष्ठ = A sea captain.

नियमिक-शास्त्र = Science of Navigation Sūrpāraka Jātaka).

निवर्तन = A river meander (Jātaka No. 208).

निवेष्प = Whirlpool (Taittirīya Sanhitā IV. 5. 9. 1).

निष्यन्द = A rillet (Rāmāyaṇa II. 94. 13).

नीप = A skirt of a mountain (Vājasaneyi-Sanhitā XVI. 37 to 54).

प

पक्ष = A foot-path (Mānasāra, chap. IX).

पत्तन वा पट्टन = A harbour (Buddhist literature, Chariyāpitaka 1.2).

पथ = A road (Vājasaneyi-sanhitā, XVI. 37 to 45).

परिलेखन = Cartography (Sūryasiddhānta and other siddhāntas).

पल्वल = A marshy area.

पहम = Shelving beach (Dīghanikāya, Part. I, p. 283).

पुष्करावर्त = An altostratus cloud (Matsya chap. 125, Brahmāṇḍa chap. 22).

पृष्ठ्या = East-west line (Vedic literature).

पोत = A sea going big vessel.

प्रतिसूर्य = Perihelion.

प्रपथ = A broad road (Vājasaneyi-sanhitā, XVI. 37 to 45).

प्रवत = Sloping tracts (Bloomfield Atharvaveda, XII. 1).

प्रवण = Undulating ground (Taittirīya Sanhitā, VI. 2. 6. 4).

प्रवहण = A particular type of ship (Kathāsaritsāgara, III. 4. 296).

प्रालेय = Sleet.

प्लव = Slope.

ब

बहूमूल = Wavy hair (Vṛhatsanhitā, chap. 67).

बालूकागिरि = A sand dune (Padma P. Sṛṣṭikhaṇḍa, 43. 181).

ब्रह्मज = Cumulo-nimbus cloud (Matsya, chap. 125, Brahmāṇḍa chap. 22).

ब्रह्माण्ड = Universe.

भ

भिन्द्य = A turbulent river breaking its bank (Pāṇini, III. 1. 115).

भुवनकोश = Science of Geography, Geography (Purāṇas etc.).

म

मण्डलीवात-मण्डलीकावात = Whirl wind (बवंडर, Vinayapitaka, Vol. III, V. 9. 4 and other Buddhist texts).

मध्यरेखा = O° longitude, prime meridian, Siddhānta-śiromaṇi, Madhyamādhikāra, Verse 2.

महामार्ग = A large road (Mānasāra, chap. IX).

मार्ग = A smaller road (Mānasāra, chap. IX).

मिहिका = Frost (Childers' dictionary).

य

यान = A kind of ship (Samaraiccakahā and Jātakamālā).

र

रथ्या = A road (Mānasāra, chap. IX).

रेखाचित्र = A plan [Aparājitapṛcchā Sūtra 2 (27)].

ल

लम्बक = Plumb, plumbbob (साहुल — Āryabhātīya, Gaṇitapāda Ś. 13).

लेख्य = A map or diagram (Vāyu P. 53. 123),

लेश्या = Light, radiation (Sūryaprajñapti, Prābhṛt 5).

लोप = A rugged tract (Taittirīya Sanhitā, IV. 5. 9. 1).

व

वण्णक = A dyke (Dīpavaṅśa, p. 212).

वहन = A special kind of ship (Smaraiccakahā and Jātakamālā).

वातातप = Loo, hotwind (Milindapañho, IV. 6. 55).

विपाट् = A meandering river (Gopatha-brāhmaṇa II. 8).

विस्फूर्जथु = A thunderclap or thunderstorm.

वीथी = A street (Mānasāra, chap. IX).

वेला = Tides (Jātaka No. 433).

वेलाकुल = A port (Samarāiccakahā, p. 202).

वोहित्थ = A special kind of seagoing vessel (Samarāiccakahā).

श

शर्करिल = Pebbly.

शाखानगर = A satellite town (Aṅgavijjā, chap. 29).

शिला = A stony place (Taittirīya Sanhitā, IV. 5. 9. 1).

शुल्वकर्म = Survey work.

शुल्वशास्त्र = Science of survey, Surveying.

शैलप्रस्थ = A plateau (Rāmāyaṇa II. 94. 11).

शृङ्गानिल = Mountain wind (Kalhaṇa VIII. 2763).

स

संदृष्टि = A sketch or diagram (a Jain term).

संपुटक = A map or a collection of maps. Atlas (Vṛhatkathā—Ślokasaṅgraha 19. 107).

सम = A plain area (Atharvaveda, XII. 1).

समरेखा = O° longitude, Prime meridian Siddhāntaśekhara II. 95-97.

समुद्र वात = Ocean breeze (Jambūdvīpaprajñapti—Commentary, p. 191).

समुद्र-संयान = Mid ocean navigation (Baudhāyanasmṛti II. 1. 1. 2).

सलिल = Ocean current (Jātakamālā, p. 127).

सलिलवात = Monsoon (Atharvaveda, Vedic Index).

सांयात्रिक = An ocean trader (Pañcatantra).

सानु = A plateau, a summit.

सार्थवाह = A caravan.

सितोपल = Marble (Padma P. Uttarākhaṇḍa, 221. 10).

सूर्व = Good soil Vājasaneyi-saṁhitā, XVI. 37 to 45).

सृति = A small path (Ṛgveda).

स्रुति = A small path (Vājasaneyi-sanhitā, XVI. 37 to 45).

स्फटिक = Quartz.

ह

हिमस्रथ = Melting of snow (Pāṇini, VII. 4. 29).

हिमानी = A glacier (Pāṇini, IV. 1. 49).

ह्रद = A lake (Taittirīya Sanhitā, IV. 5. 9. 1).

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ABBREVIATIONS

Apsl=Āpastamba Śulvasūtra.

AV=Atharvaveda.

BI=Bibliothica Indica.

BSL=Baudhāyana Śulvasutra.

HOS=Harvard Oriental Series.

KS=Kātyāyana Śulvasutra.

MS=Maitrāyanī Sanhītā.

PTS=Prākṛta Text Society, Pāli Text Society.

RV=Ṛgveda.

SB=Śatapatha Brāhmaṇa.

SBB=Sacred Books of Buddhists.

SBE=Sacred Books of East.

SBH=Sacred Books of Hindus.

SV=Sāmaveda.

TS=Taitirīya Sanhita.

YV=Yajurveda.

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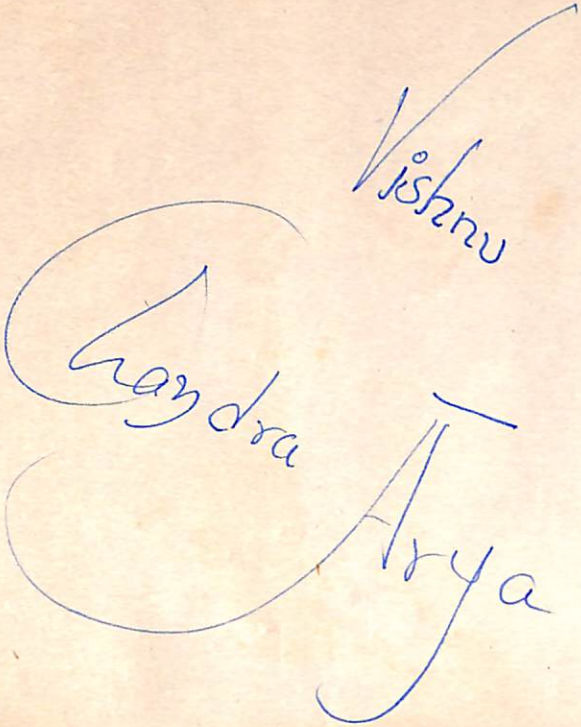
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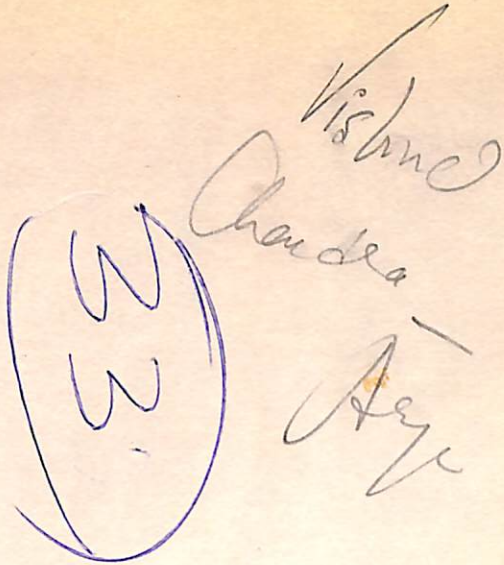
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